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## SECOND INTERIM REPORT

### INVESTIGATION OF ODOROUS AND VOLATILE COMPOUNDS FOR BBK CLASS I LANDFILL SITE IN THE CITY OF WEST COVINA

Prepared for:

BKK Corporation  
3031 East I Street  
Wilmington, California 00744

by:

Environmental Engineering Program  
University of Sourthern Califronia  
Los Angeles, California 90007

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## EXECUTIVE SUMMARY

This Interim Report covers the study of odorous substances and volatile organic compounds from BKK Class I Landfill Site in the City of West Covina. The major findings are:

1. The major source of odor from the landfill site was found to be mainly from the acid wells and the working face. Hydrogen sulfide was found to be the major identifiable odorous substance. Its concentration was found to range from 0 to 5.75 ppb. Other odorous compounds are generally present well below threshold concentrations. The ACGIH (American Conference of General Industrial Hygienists) recommended hydrogen sulfide threshold limit value (TLV) for a worker exposure of 8-hours, is  $15 \text{ mg/m}^3$  (10 ppm or 10,000 ppb). The presence of hydrogen sulfide seems to be more of an aesthetic problem than a health hazard. Installation of caustic scrubbing devices for the acid wells will greatly reduce the emission of hydrogen sulfide as well as other acid vapors.

2. The major sources of volatile organic compounds seem to be mainly from the working face, with minor contributions from the gas burner. Among all organic components identified, benzene and chloroform are known to be carcinogenic in nature. There are no other identifiable suspected carcinogens. Chloroform concentrations range from below detection limits in the residential area to  $190 \text{ } \mu\text{g/m}^3$  in the working area during the disposal operation, with an averaged value of  $15 \text{ } \mu\text{g/m}^3$ . Among

all the measurements performed during the evening, only one sample was found to be above the detection limit. Among the day-time samples, chloroform was mostly detected within the landfill area.  $3 \mu\text{g}/\text{m}^3$  and  $14 \mu\text{g}/\text{m}^3$  were detected in readings of two samples in the residential area. The NIOSH permissible occupation level is  $240 \text{ mg}/\text{m}^3$  (50 ppm) for an 8-hour daily exposure. (1 mg = 1,000  $\mu\text{g}$ .)

The concentration of benzene in all samples ranged from below the detection limit in the residential area to a maximum of  $364 \mu\text{g}/\text{m}^3$  around the working face during disposal of liquid waste. The ACGIH/TLV is  $80 \text{ mg}/\text{m}^3$  (25 ppm) for worker exposure of 8-hours.

3. The presence of chlorinated organic substances in air samples seem to be more prevalent than generally recognized. Concentrations of 0.1 to  $0.7 \text{ mg}/\text{m}^3$  were observed. The major sources appear to be the working face, gas burner, and possibly acid wells. The significance of the presence of these compounds is unknown. Scrubbing gaseous effluents of both burner and acid wells will reduce the emission.

4. The emission of other organic substances, generally hydrocarbons from the working face, may not pose any health or odor problem; however, the significance and magnitude of these emissions in terms of air quality degradation need to be assessed.

5. Probably the most important factor in reducing the emission of volatile organic substances is the reduced exposure of disposed liquid wastes in the working face. Some operational

guidelines in restricting the maximal time of exposure as well as the size of the working face may be necessary.

6. The maintenance of combustion temperature of the gas burner at 1400<sup>0</sup>F since last Report has resulted in improvement in the odor emission from the landfill based on analytical data obtained as well as reduction in the number of complaints. The odor emitted from this source was estimated to be about 28% of the total complaints. (p.7, First Interim Report.) Installation of an afterburner or scrubbing or exhaust gases can result in additional removal of organic compounds.

7. The next phase of study should include:

- a. Identification of major sources of chloroform and benzene in incoming liquid wastes.
- b. Study of alternative disposal practices, e.g., selective discharge of benzene and chloroform-containing wastes in deep wells; reduced exposure time of selective liquid wastes.
- c. Study of operational guidelines to reduce the emission of volatile substances during the disposal operation.
- d. Possible chemical treatment of selective incoming wastes.

In summary, improvement in the odor and emission of organic compounds can be made through incremental implementation of source control within the landfill. At present, the problems associated with the BKK Landfill seem to be aesthetic in nature, based on established health standards.

## I. INTRODUCTION

The report presented here, is the second part of a comprehensive study for the identification and control of odor of the Class I Landfill in the City of West Covina, in accordance with the Preliminary Study Plan presented to the BKK Corporation. The first Interim Report covered mainly: Task 1 (Survey of Historic Data and Selection of Sampling Conditions); Task 2 (Preliminary Site Survey); Task 3 (Development of Field Sampling Techniques); and Task 4 (Development of Analytical Techniques). This second Interim Report mainly describes Tasks 5 and 6, which include sample collection and analysis, and formulation of corrective solutions based upon the interpretation of the collected data.

Although the original objective of this study was to investigate the odor problem, the scope of work was expanded to include the determination and control of volatile organic compounds from the landfill, with special attention to the identification of known carcinogens. Specific objectives covered in this phase are as follows:

- To identify the major sources of the odorous and volatile organic compounds.
- To determine the intensity of odor and concentrations of possible carcinogens based on both instrumental and chemical analyses.
- To monitor the dispersion patterns of both odorous and volatile organic compounds.

- To develop control techniques to reduce the emission of odorous and volatile organic compounds.

The problems of odor generation and emission of volatile organic compounds associated with the integrated disposal of solid and liquid wastes in Class I Landfills, have created an unique need for the development of effective landfill emission control measures. Odor problems arise when gases and vapors from industrial wastes and/or decomposed organic matter are dispersed under favorable meteorological conditions.

There are innumerable odors in airborne gases and vapors resulting from various concentrations and intensities of each odorous constituent. As these odorous gases and vapors travel downwind, they may be intensified by reaction with other gases, vapors, or particulate matter.

The most frequently emitted odors from the anaerobic decomposition of organic matter are hydrogen sulfide, ammonia, methylmercaptans, methylsulfides, amines, indole, skatole, and, to a lesser extent, sulfur dioxide, phenolics, and chlorine compounds. Some organic acid, aldehydes, and ketones may also be odorous either individually or in combination with other compounds. Organic matter under anerobic conditions, will produce odors that have been characterized by different people as rancid, feral, rotten eggs, cabbage-like, skunk-like, et cetera.

Potential odor problems arising from the disposal of chemical industrial wastes include sulfur containing compounds, nitrogenous compounds, oxygenated compounds (carbonyls, esters, car-

boxylic acids, alcohols), substituted ethylenic compounds, and benzenoid compounds. Odor descriptions of these various compounds include sweet, sour, onion, garlic, fishy, solvent, sulfidy, burnt rubber, earthy, rotten eggs, hay/straw-like, moth balls, tar-like, shoe polish, medicinal, floral, mustard, hot plastic.

Although the presence of toxic and odorous compounds at the landfill site was difficult to detect because of sampling and analytical difficulties, with the recent advance of analytical instruments, such as gas Chromatography/Mass Spectrometry, it is possible to separate and identify the major components of the organic mixtures both at the site and its vicinity, even in trace quantities.

## SECTION II

### SAMPLING AND ANALYSIS

#### A. METHODS OF APPROACH

Identification and quantification of odor is very difficult. Not only is odor caused by very minute quantities of substances, but also the only good measuring device is the human nose, which is notoriously undependable. Further, people have mixed reactions with respect to the offensiveness of odors.<sup>1</sup>

The magnitude of the human sensory responses to odor (the perceived odor intensity) decreases as the concentration of odorant decreases. However, the relationship between odor intensity and odorant concentration is by no means a direct proportion.

Perceived odor intensity decreases rapidly during the course of a continuous exposure; this is the phenomenon of adaptation to odor. The sensitivity to odor is recovered when the exposure is removed. Both of these processes, adaptation and recovery, operate over short time scales. Habituation to odors, however, operates over much longer periods.<sup>2</sup>

Quantitative analysis of odor is more an art than an exact science. In early 1950, Professor Gordon M. Fair of Harvard University, designed a device for odor measurement. Since then, little progress was made in the measurement of odor. With the recent advances in the measurement of trace substances, organic compounds in minute quantity which are associated with emitting odor can be quantified through a "Gas Chromatography-Mass Spectro-

meter" (GC-MS) technique. Inorganic substances, such as hydrogen sulfide, can be concentrated and analyzed either by wet chemical or instrumental analysis.

Odor threshold is defined as the minimum physical intensity of stimulus which elicits a response 50% of the time. Some of the specific odor producing substances, with corresponding odor thresholds and descriptions, are shown in Table I.<sup>3</sup> With the exception of the compounds marked with an asterisk, for which special procedures are required, these substances can be detected by GC-MS technique at the threshold concentration.

In general, odor from landfill is described as "trashy" odor with little specificity. It is possible that odor from landfill is a combination of minute quantities of diffuse compounds, some of which may not be detectable even with modern instrumentation. Hydrogen sulfide and volatile organics were selected in this study as the compounds most responsible for odor generation as shown in Table I.

As mentioned above, extension of the scope of work resulted in greater emphasis on volatile organic investigations. These compounds were examined not only for their nuisance odor effects, but also as potential health hazards to the environment. A very important category in this group are the suspected carcinogens.

This report represents a pioneering effort to identify and quantify minute quantities of compounds from landfills. The study of the BKK Landfill in West Covina, is of special significance because the site receives both domestic and industrial wastes which can emit odorous volatile organic compounds in addition to end products from anaerobic decomposition.

TABLE 1  
ODOR THRESHOLDS IN AIR (ppm, FROM REFERENCE 3)

CHEMICAL	ODOR THRESHOLD	ODOR DESCRIPTION
Acetaldehyde	0.21	Green sweet
Acetic acid	1.0	Sour
Acetone	100.0	Chemical sweet, pungent
Acrolein	0.21	Burnt sweet, pungent
Acrylonitrile *	21.4	Onion-garlic-pungency
Allyl chloride	0.47	Garlic-onion pungency, green
Amine, dimethyl*	0.047	Fishy
Amine, monomethyl*	0.021	Fishy, pungent
Amine, trimethyl*	0.00021	fishy, pungent
Ammonia*	46.8	Pungent
Aniline	1.0	Pungent
Benzene	4.68	Solvent
Benzyl chloride	0.047	Solvent
Benzyl sulfide	0.0021	Sulfidy
Bromine	0.047	Bleach, pungent
Butyric acid	0.001	Sour
Carbon disulfide	0.21	Vegetable sulfide
Carbon tetrachloride	21.4	Sweet, pungent
Chloral	0.047	Sweet
Chlorine*	0.314	Bleach, pungent
Dimethylacetamide	46.8	Amine, burnt, oily
Dimethylformamide	100.0	Fishy, pungent
Dimethyl sulfide*	0.001	Vegetable sulfide
Diphenyl ether (perfume grade)	0.1	

(Continued)

CHEMICAL	ODOR THRESHOLD	ODOR DESCRIPTION
Diphenyl sulfide *	0.0047	Burnt rubbery
Ethanol (synthetic)	10.0	Sweet
Ethyl acrylate	0.00047	Hot plastic, earthy
Ethyl mercaptan *	0.001	Earthy, sulfidy
Formaldehyde *	1.0	Hay/straw-like, pungent
Hydrochloric acid gas *	10.0	Pungent
Hydrogen sulfide gas *	0.00047	Rotten egg
Methanol	100.0	Sweet
Methyl chloride *	(above 10 ppm)	-
Methylene chloride	214.0	-
Methyl ethyl ketone	10.0	Sweet
Methyl isobutyl ketone	0.47	Sweet
Methyl mercaptan	0.0021	Sulfidy, pungent
Methyl methacrylate	0.21	Pungent, sulfidy
Monochlorobenzene	0.21	Chlorinated, moth balls
Nitrobenzene	0.0047	Shoe polish, pungent
Paracresol	0.001	Tar-like, pungent
Paraxylene	0.47	Sweet
Perchloroethylene	4.68	Chlorinated solvent
Phenol *	0.047	Medicinal
Phosgene *	1.0	Hay-like
Phosphine *	0.021	Oniony, mustard
Pyridine	0.021	Burnt, pungent, diamine
Styrene (inhibited)	0.1	Solventy, rubbery
Styrene (uninhibited)	0.047	Solventy, rubbery, plasticity
Sulfur dichloride	0.001	Sulfidy
Sulfur dioxide *	0.47	pungent
Toluene (from coke)	4.68	Floral, pungent, solventy
Toluene (from petroleum)	2.14	Moth balls, rubbery
Tolylene diisocyanate *	2.14	Medicated bandage, pungent
Trichloroethylene	21.4	Solventy

## B. SITE DESCRIPTION AND SAMPLING PLAN

The BKK Landfill Site was established and certified as a Class I and II sanitary landfill by the State of California Regional Water Quality Control Board in 1963. It disposes of 1500 tons of industrial liquid waste and 3000 tons of solid wastes daily. The following types of waste are received:

Agricultural	Rubber Tires
Commercial	Solid Fill
Demolition	Street and Park
Household	Wood and Lumber
Industrial (Liquid and Solid)	

Industrial solid and liquid chemical wastes include all types of wastes except for radioactive compounds and polychlorinated biphenyls (PCB's). The site has a calculated capacity of 900,000,000 cubic yards and is expected to be filled in about 40 years.

Due to spatial and temporal variations of odor emissions, and since selection of adequate sampling stations could, to a great extent, determine the success of the study, special care was taken in selecting the sampling sites. Fifteen sampling stations were established, located both within the site boundary and in the surrounding residential area. Sampling site selection was based on the following considerations:

- Previous complaint data.
- Major emissions of odorous and volatile organic compounds generated by the working face, liquid disposal wells and gas burners.
- Meteorological factors. These include wind

direction and velocity, relative humidity,  
and inversion heights.

Time of sampling (related to inversions).

Overall, fifty-four sets of sampling were performed between November 1979 and June 1980. Correlations between meteorological data, time of day, and solar radiation were established in previous investigations (please refer to Figures 18-34 in the previous Interim Report).

The location of the sampling stations is identified in Figure 1.

An important parameter in odor dispersion is the presence of inversions. Commonly, atmospheric temperature decreases as altitude increases, favoring dispersion of odorous compounds, because air masses at the surface are warmer, have lower density, and rise. However, the ground heats or cools faster than air. This causes a radiation inversion in relatively stable air at night, because the ground cools first, and air at or near the earth-atmosphere interface is cooler than the upper layers, thereby inhibiting dispersion. This process continues as long as skies are clear and winds are low. As the sun rises the following morning, the ground warms up faster than the air, and the inversion soon dissipates. It is believed that stagnant air at night is responsible for the increased number of complaints experienced at that time.

Proper procurement of samples is also important. Precise field sampling techniques have to be developed, in order to produce consistent analytical results. Quality control procedures

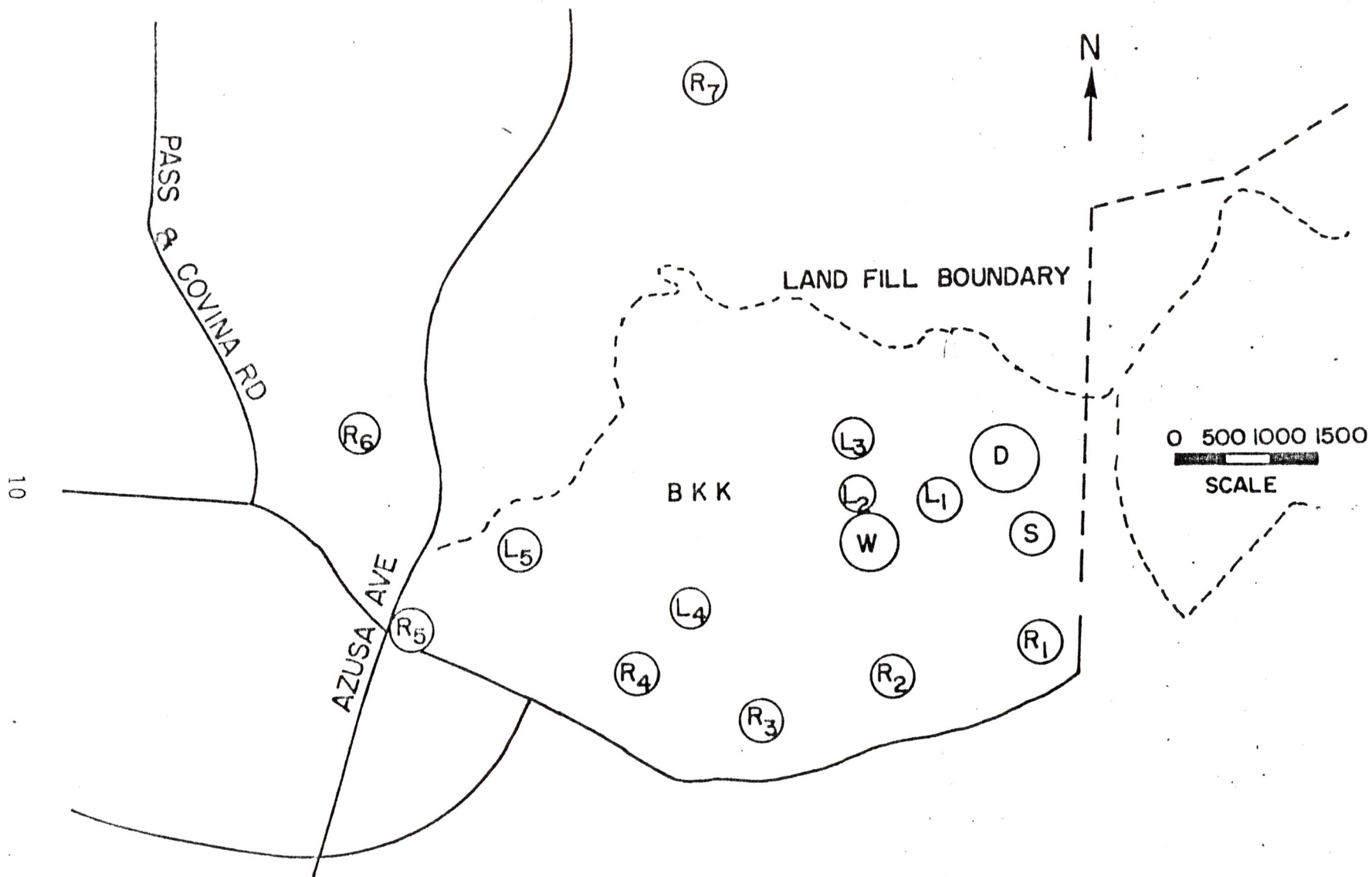


Figure 1 - Location of Sampling Stations (Legend on Next Page)

Figure 1 - Legend

L = Sampling station in landfill area

R = Sampling station in residential area

S = Meteorological station (wind measurements)

W = Working face

D = Liquid disposal wells

L1 = Near gas burner, 100 m from working face

L2 = 50 m from working face

L3 = 250 m from working face

L4 = Main road to working face

L5 = Entrance to BKK Landfill

have to ensure that the samples are representative of actual in situ conditions. All samples were collected in a downwind direction with respect to the working face, unless otherwise specified. Daily, weekly, and seasonal samplings were performed to cover the variety of environmental and seasonal conditions. Samples were analyzed for volatile organic compounds and hydrogen sulfide.

#### C. METHODS OF SAMPLING AND ANALYSIS

##### 1. HYDROGEN SULFIDE

Sampling was performed by a suction pump, using an extended sampling time of 30 to 60 minutes corresponding to air flows of 300 to 600 l/min. Overall, 50 samples for the measurement of hydrogen sulfide were taken.

Hydrogen sulfide analyses were performed by an iodometric method for the first batch of 5 samples. This method is based on absorption of the gas sample in an impinger containing a standardized solution of iodine and potassium iodide, which oxidizes the hydrogen sulfide. However, this solution will also oxidize sulfur dioxide, which is usually present in the contaminated ambient air. Both gases are relatively stable when present in low concentrations. The unreacted or excess iodine is estimated subsequently by titration with standard sodium thiosulfate solution. Sulfur dioxide may be oxidized separately to sulfuric acid by a dilute acid solution of hydrogen peroxide; (and subtracted from the total;) hydrogen sulfide will not interfere if the solution is acidic.

A modification of the iodometric method was used for the second batch of 8 samples, since the original method was found not sensitive to low levels of hydrogen sulfide. A known volume of air was passed through a solution of ammonia-cadmium chloride contained in two bubblers connected in series. The collected samples were then stripped by aeration of any sulfur dioxide that could have been trapped, and the cadmium sulfide precipitated was dissolved in concentrated hydrochloric acid. This solution was then titrated with standard iodine solution, using starch as an indicator. In order to detect the low level of hydrogen sulfide in the air, a more sensitive colorimetric method was employed for samples 14 to 50, using Mine Safety Appliance (MSA) hydrogen sulfide detection tubes. These tubes were connected to a suction pump, and a limiting orifice was used to control the volume of air flow. Figure 2 shows the correlation between orifice differential pressures and flow rates.

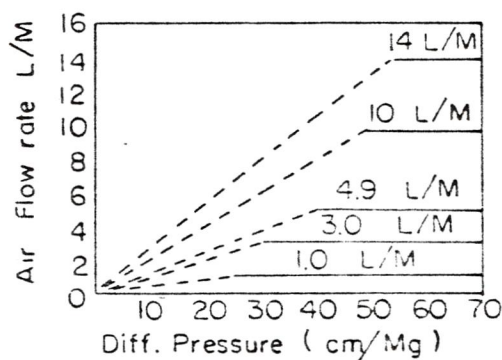


Figure 2 - Air Flow - Orifice Differential Pressure Correlation, MSA Detector Tubes.

These correlations were used to determine flow rates and total collected volume of each sampling. With this newly developed method, sensitivity for analyzing low concentration of hydrogen sulfide is greatly improved. The procedure is based on color changes occurring in the reaction between hydrogen sulfide and silver cyanide. Each lot of tubes is separately calibrated over the certified range using standards. The length which developed a color is correlated to the hydrogen sulfide concentration.

## 2. VOLATILE ORGANICS

### a. Sampling

Sampling for volatile organics requires:

- Efficient concentration of volatiles from a large air sample with no interference from moisture.
- Complete collection in the volatile range considered and quantitative regeneration.
- Storage capability for later analysis.
- Short sampling interval to observe rapid compositional changes.

Sampling for volatile organics was performed using Tenax - GC 2, 6 diphenyl-p-phenyleneoxide polymer, which was found capable of meeting these requirements. This product was originally developed for gas chromatographic column packing; it is also an excellent material for absorbing volatiles from air for subsequent analysis. Because of its good thermal stability (it withstands temperatures up to 350°C), Tenax - GC can be employed for the

collection and desorption of volatile substances with molecular weights ranging up to several hundreds, making it suitable for trace analysis of biologically important volatiles and air pollutants.

Since the concentrations of volatile organics at the BKK Site are generally very low, Tenax - GC was used to concentrate volatiles present in the air at the sampling stations.

The trapping apparatus consisted of a pyrex glass tube, 11 cm X 8 mm ID X 10 mm OD, partially packed with 2 ml of Tenax - GC. The Tenax - GC trap was first pre-conditioned with a helium flow of 30-50 ml at 375°C for 30 minutes, then connected to a suction pump in the sampling station. Sampling time varied between 10 to 30 minutes depending on the suspected concentration of odorous compound present at the station. Precalibration of the tube was performed using a soap bubble flowmeter. The sample is obtained by pulling air through the tube at a known rate. After a suitable period of sampling, the pump was turned off, and the tube capped or stored until the analysis could be performed.

b. Analysis

Analysis of volatile organics was performed using the Gas Chromatography-Mass Spectrometer (GC/MS) procedure. In this procedure a gas chromatograph produces specific peaks for the compounds present, which are proportional to their concentration, and the Mass Spectrometer identifies the individual compounds.

The application of a Mass Spectrometer as a universal yet extremely selective and sensitive detector in gas chromatography has revolutionized the identification and measurement of organic compounds. The GC/MS procedure provides a "broad spectrum" organic analysis of both major and minor components, and is highly suited to the identification and quantification of the broad spectrum of organic materials likely to be present in the landfill air samples.

The samples collected were analyzed using a Finigan 3200 Gas Chromatograph-Mass Spectrometer, courtesy of the Analytical Research Laboratory. The samples underwent direct heat desorption at 200°C for 10 minutes under a 30 cm/min helium flow. At the end of 10 minutes, the Tenax sample tube was removed and the analytical column rapidly heated to 50°C. At the end of 20 minutes, the column was temperature programmed at 8°C/min to 165°C, then held at that temperature. The detection limits were around 1-10 µg/m<sup>3</sup> air. The computer-assisted Mass Spectrometer assigned identifications and printed the relative amounts of each constituent present in the original sample.

## SECTION III

### RESULTS AND DISCUSSION

#### A. OLFACTORY ODOR

Odors may affect well-being by eliciting unpleasant sensations, by triggering possibly harmful reflexes and other physiologic reactions, and by modifying the olfactory function.

One of the methods performed to evaluate the extent of odor nuisance in the landfill and its vicinity was a simple estimation of olfactory odor range. Estimation of odor presence in the sampling stations was done by a trained technician, who attempted to categorize the odor extent in a scale of 0 to 3, according to odor intensity, as follows:

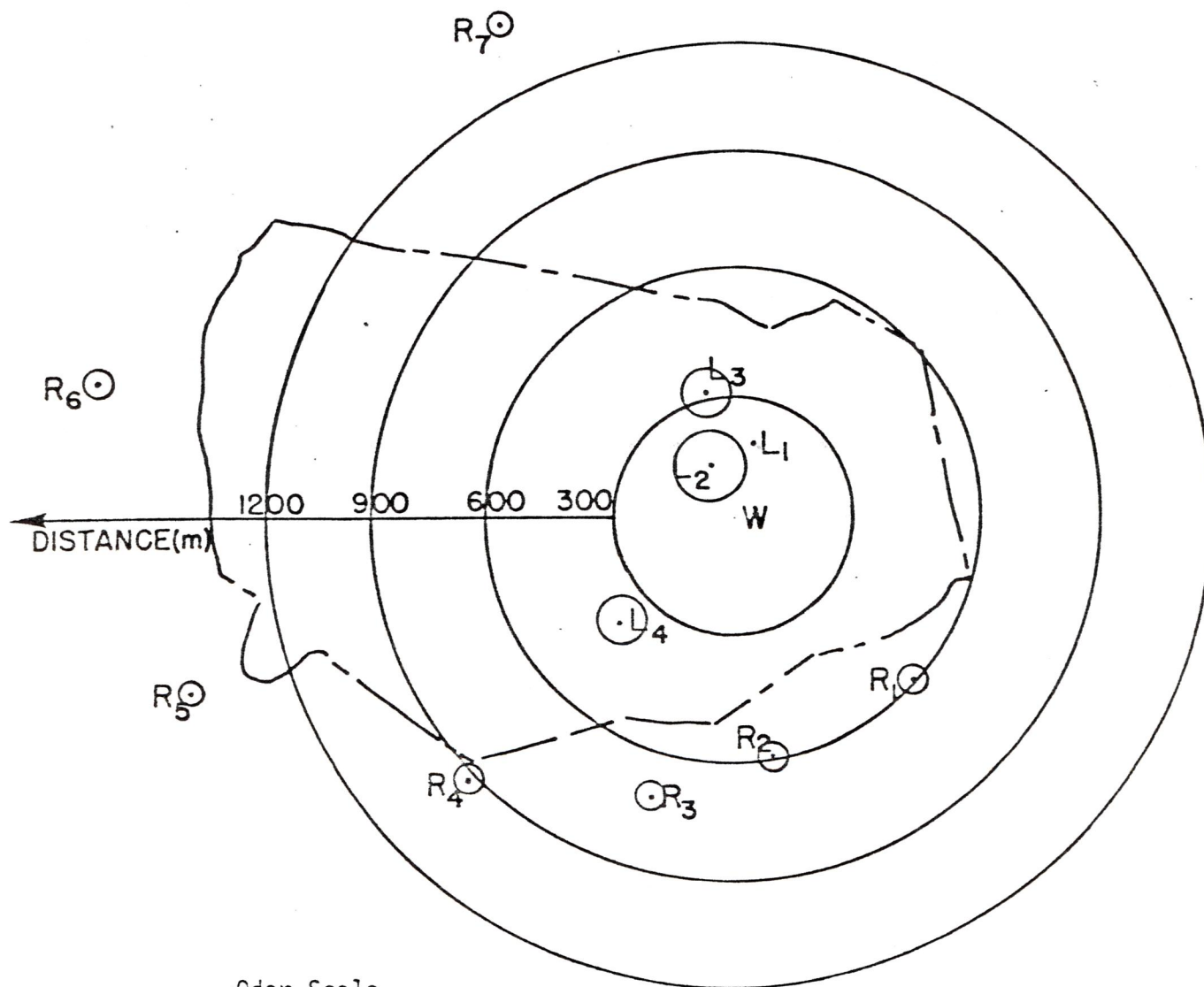
- 0 = no odor present
- 1 = weak odor present
- 2 = moderate odor present
- 3 = strong odor present.

These estimations were performed simultaneously with actual samplings, while endeavoring to assess concentration fluctuations between day and night, different days of the week, and different seasons.

Figures 3 and 4 present the extent of olfactory odor estimated during day and night time, respectively.

A comparison between the two figures indicates higher odor presence during night-time in the majority of sampling stations. These observations support both the results from the first In-

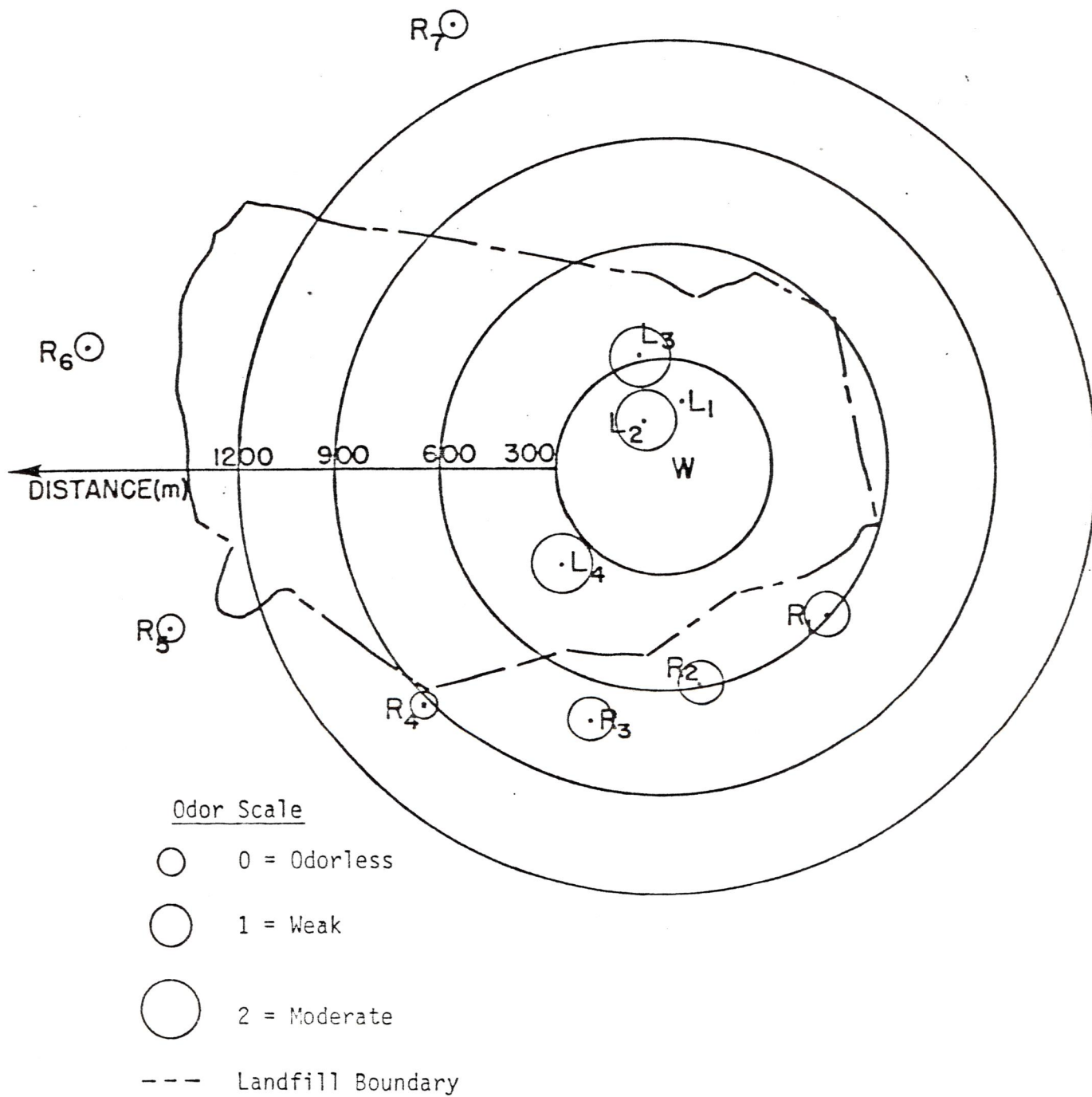
Figure 3 - Odor Detection by Olfactory Estimation During the Day.



Odor Scale

- 0 = Odorless
- 1 = Weak
- 2 = Moderate
- Landfill Boundary

Figure 4 - Odor Detection by Olfactory Estimation During the night.



terim Report pointing out an increase in complaint numbers during the night, and the assumption that night-time radiation inversion prevents dispersion and dilution of odorous compounds.

The bar chart in Figure 5, shows a strong positive correlation between odor extent and proximity to the working face for various locations during day-time. However, due to the fact that acid wells and gas burners are located in the vicinity of the working face, it was difficult to determine the relative contribution of each source. Exhaust gases from gas burner were analyzed and found to be free of odorous substances. Olfactory detections and sample analyses indicate that acid well is a major source of odor emission.

Figure 6, comparing estimated olfactory odor with the concentration of volatile organics, also confirms this important conclusion: no correlation exists between the total volatile organic concentration and the extent of odor. This indicates that odor and volatile organic compounds are not necessarily emitted from identical sources. It would be expected that total volatile organic concentrations correlate with the extent of odor detected in the area, if organics are the major source of odor problems. However, according to Figure 6, very high organic concentrations were present when the odor level was estimated "weak," while in some cases, in the presence of very low organic concentrations, odor level was estimated as "strong." It is likely that a major fraction of the odorous

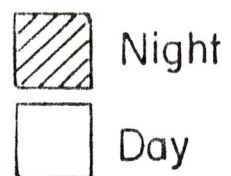


Figure 5 - Correlation Between Estimated Olfactory Odor and Working Face Distance

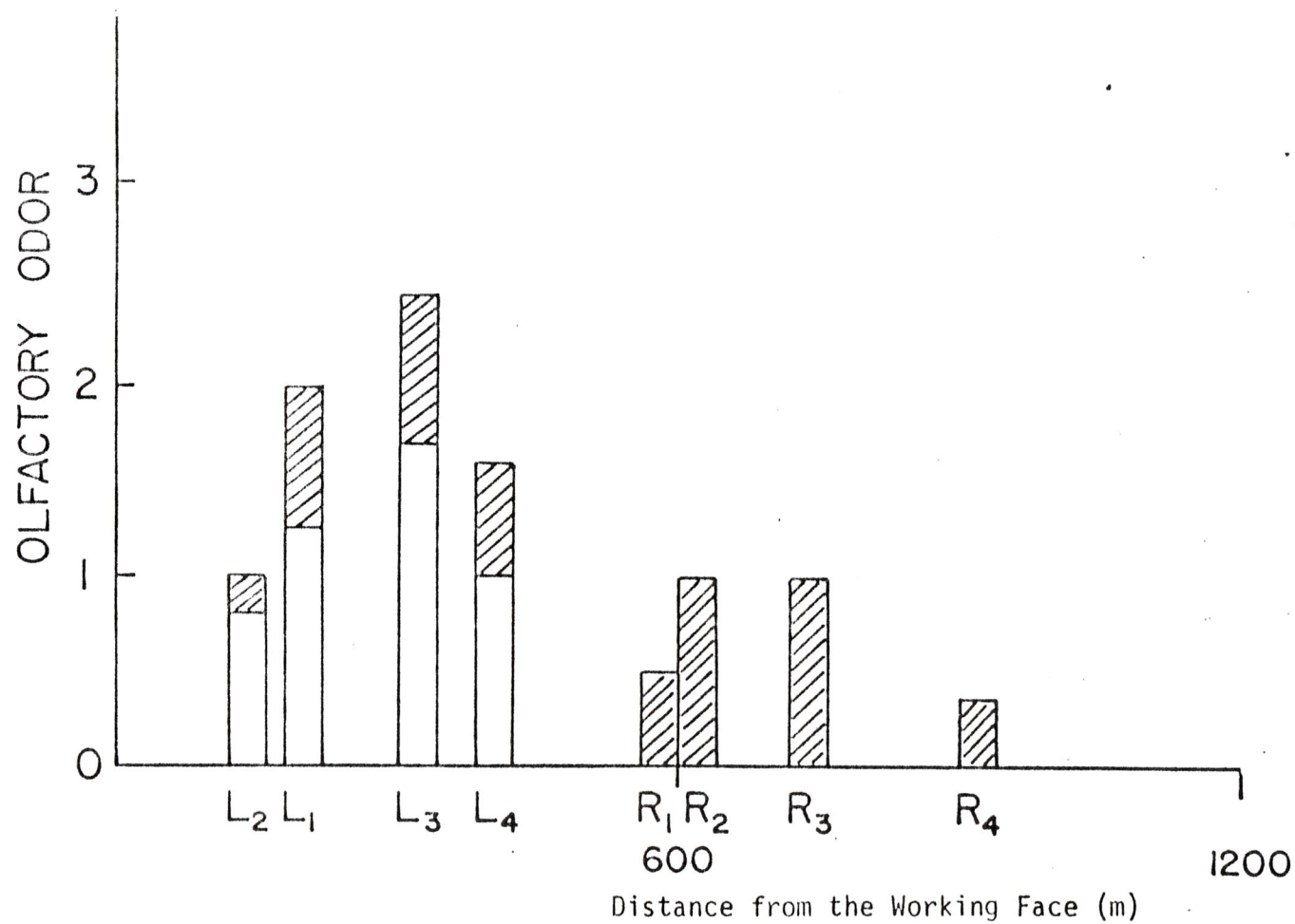
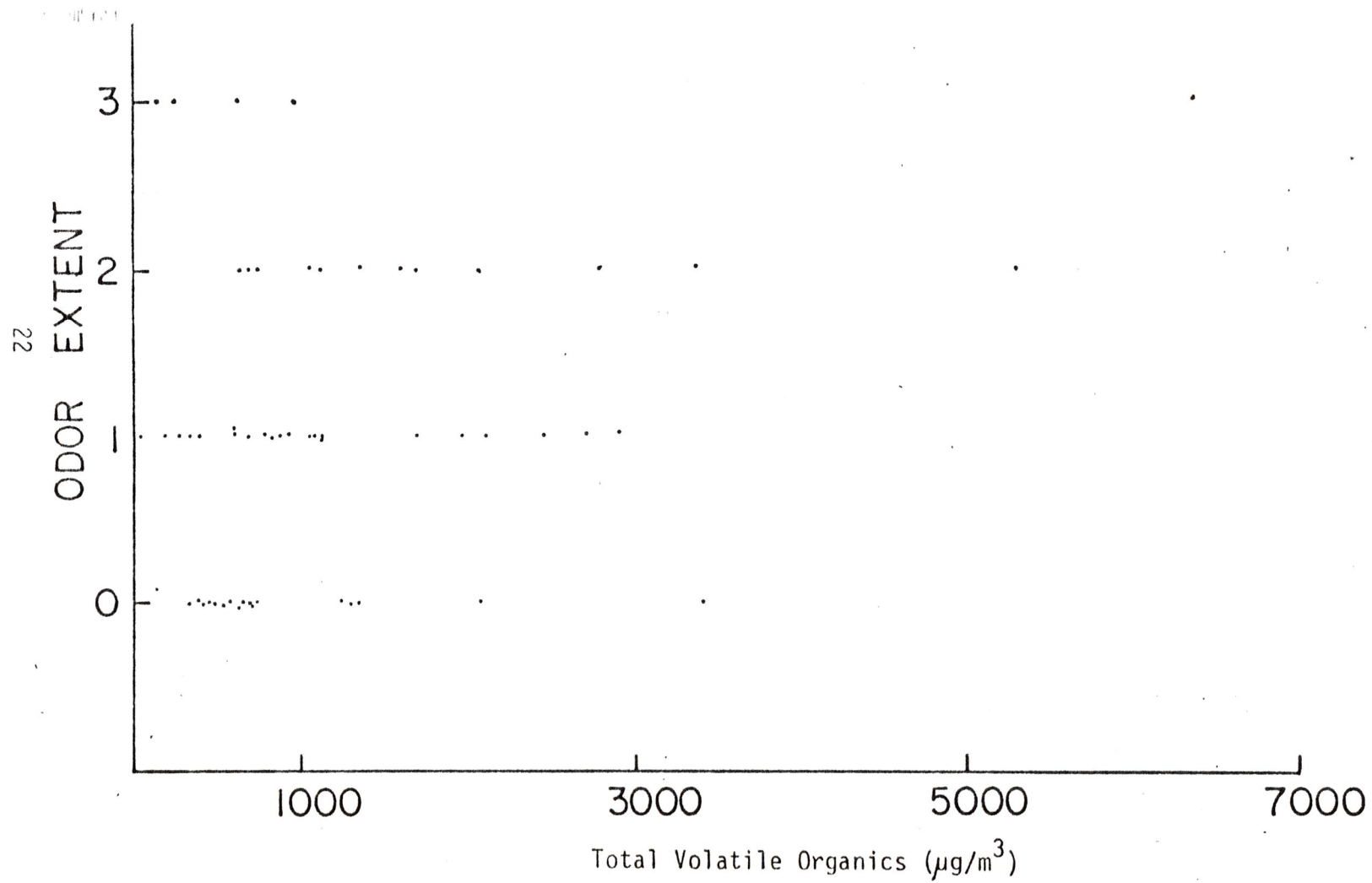


Figure 6 - Correlation Between Estimated Olfactory Odor and Concentration of Volatile Organics.



compounds is contributed by inorganic components. A comparison of threshold concentration of odor producing substances with the maximum measured values at the BKK Site, as shown in Table 2, indicates that hydrogen sulfide is the major odor producing component.

B. HYDROGEN SULFIDE

Hydrogen sulfide is a colorless gas having the characteristic odor of rotten eggs. The gas is flammable, burning in air with a pale blue flame; the ignition temperature is 260°C. Hydrogen sulfide may be generated at the BKK Landfill as a result of bacteriological decomposition of protein and sulfur-containing organic matter under anaerobic conditions. It may also be present in certain industrial wastes, or be produced from them by the sulfate reduction process or by dissolution of metal sulfides after PH reduction due to injection of acidic waste.

Hydrogen sulfide is an important odorous component for this study, since there is no odor more readily identifiable to the average individual than that of hydrogen sulfide. Very low concentrations of a few hundredth mg/l (0.01 - 0.045 mg/l) cause an objectionable rotten egg odor, and are easily detected by olfaction,<sup>6</sup> although they are not believed to be associated with significant health effects. (See below.)

Hydrogen sulfide intoxication has been classified under three headings: acute, sub-acute, and chronic. Acute intoxication is a dramatic, systemic reaction resulting from a single massive exposure to 1400 mg/m<sup>3</sup> or more of hydrogen sulfide in air. This condition is characterized by rapid (often

Table 2 Threshold Concentrations of Odor Producing Substances and  
Maximum Measured Values in the BKK Site.

CHEMICAL		ODOR THRESHOLD(ppm)	MAXIMUM VALUE(ppm) (this study)
Acetaldehyde		0.21	0
Acetic acid		1.0	0.0017
Acetone		100.0	0.026
Acrolein		0.21	0
Acrylonitrile	(1)	21.4	0
Allyl chloride		0.47	0
Amine, chloride	(2)	0.047	0
Amine, monomethyl	(2)	0.021	0
Amine, trimethyl	(2)	0.00021	0
Ammonia	(1)	46.8	0
Aniline		1.0	0
Benzene		4.68	0.114
Benzyl chloride		0.047	0
Benzyl sulfide		0.0021	0
Bromine	(4)	0.047	0
Butyric acid		0.001	0
Carbon disulfide		0.21	0.0032
Carbon tetrachloride (chlorination of CS <sub>2</sub> )		21.4	0.036
Carbon tetrachloride (chlorination of CH <sub>4</sub> )		100.0	0
Chloral		0.047	0
Chlorine	(1)	0.314	0
Dimethylacetamide		46.8	0
Dimethylformamide		100.0	0
Dimethyl sulfide	(2)	0.001	0
Diphenyl ether (perfume grade)		0.1	0

<u>CHEMICAL</u>	<u>ODOR THRESHOLD</u>	<u>MAXIMUM MEASURED VALUE (PPM)</u>
Diphenyl Sulfide	0.0047	0
Ethanol (synthetic)	10.0	0
Ethyl Acrylate	0.00047	0
Ethyl Mercaptan	0.001	0
Formaldehyde	1.0	0
Hydrochloric Acid Gas	10.0	0
Hydrogen Sulfide (from Na <sub>2</sub> S)	0.0047	0
Hydrogen Sulfide Gas	0.00047	0.0057*
Methanol	100.0	0
Methyl Chloride	(above 10 ppm)	0
Methylene Chloride	214.0	0
Methyl Ethyl Ketone	10.0	0.005
Methyl Isobutyl Ketone	0.47	0
Methyl Mercaptan	0.0021	0
Methyl Methacrylate	0.21	0
Monochlorobenzene	0.21	0
Nitrobenzene	0.0047	0
Paracresol	0.001	0
Paraxylene	0.47	0
Perchloroethylene	4.68	0
Phenol	0.047	0
Phosgene	1.0	0
Phosphine	0.021	0
Pyridine	0.021	0
Styrene (inhibited)	0.1	0
Styrene (uninhibited)	0.047	0
Sulfur Dichloride	0.001	0
Toluene (from Coke)	4.68	0
Toluene (from Petroleum)	2.14	0
Tolylene Diisocyanate	2.14	0
Trichloroethylene	21.4	0.217

instantaneous) loss of consciousness followed by convulsions and respiratory failure caused by the paralyzing effects of the gas on the respiratory centers.

Sub-acute hydrogen sulfide poisoning is a localized response to the irritant properties of the gas following continuous exposure to concentrations between 140 and 1,400 mg/m<sup>3</sup> (100 and 1,000 ppm). Eye irritation, manifested as conjunctivitis, keratitis, or both, is the most common form of sub-acute poisoning. Respiratory tract irritation is also an effect of sub-acute poisoning. If exposure is prolonged, irritation of the deeper regions of the lung may cause pulmonary edema. Furthermore, at these concentrations hydrogen sulfide produces rapid paralysis of the olfactory apparatus, thereby neutralizing the sense of smell as a warning system.

Acute and sub-acute hydrogen sulfide concentrations are most likely to be experienced in an enclosed area, such as in a sewer system.

There is no unanimity of opinion among authors as to whether chronic hydrogen sulfide poisoning represents a discrete clinical entity. Some believe that the signs and symptoms collectively referred to as chronic poisoning, actually represent recurring acute or sub-acute toxic exposures.

A study of chronic low level exposure to hydrogen sulfide was published<sup>7</sup> showing minimal correlation between exposure to hydrogen sulfide and any chronic effects. The existing hydrogen sulfide levels in the landfill and around the residential area, at most can be considered as chronic very low level ex-

posure at irregular intervals.

The odor threshold of hydrogen sulfide is in the range of hundredth of ppm. No significant health effects are known to be observed at this level. No national ambient air quality standards have been adopted for the United States; the State of California has issued an ambient air quality standard of 0.03 ppm (0.045 mg/m<sup>3</sup>), averaged over one hour. The American Conference of Governmental Industrial Hygienists (ACGIH) has set a threshold limit value (TLV) of 15 mg/m<sup>3</sup> (10 ppm) averaged over an 8-hour work day.

Figures 7 and 8, illustrate the distribution of hydrogen sulfide concentration at the landfill site and its vicinity. A comparison between these two figures might re-emphasize the importance of the working face and acid well as the major sources of odor producing components in the landfill. During day-time operating hours, hydrogen sulfide concentrations are high close to the working face and acid wells; the levels are generally low in the residential area. During the nights, when dumping operations stop, the difference between the landfill operation area and the residential area is not so obvious. Stagnant air during the night inversion probably explains the higher levels of hydrogen sulfide in the residential area during the night.

Figure 9 presents the correlation between average hydrogen sulfide concentrations and proximity to the working face; a clearly positive correlation is observed during day-time.

The hydrogen sulfide concentrations measured are very small, ranging between 0 (below detection limits) and 5.75 ppb (0.0057

Figure 7 - Hydrogen Sulfide Concentration in the Landfill and its Vicinity During the Day.

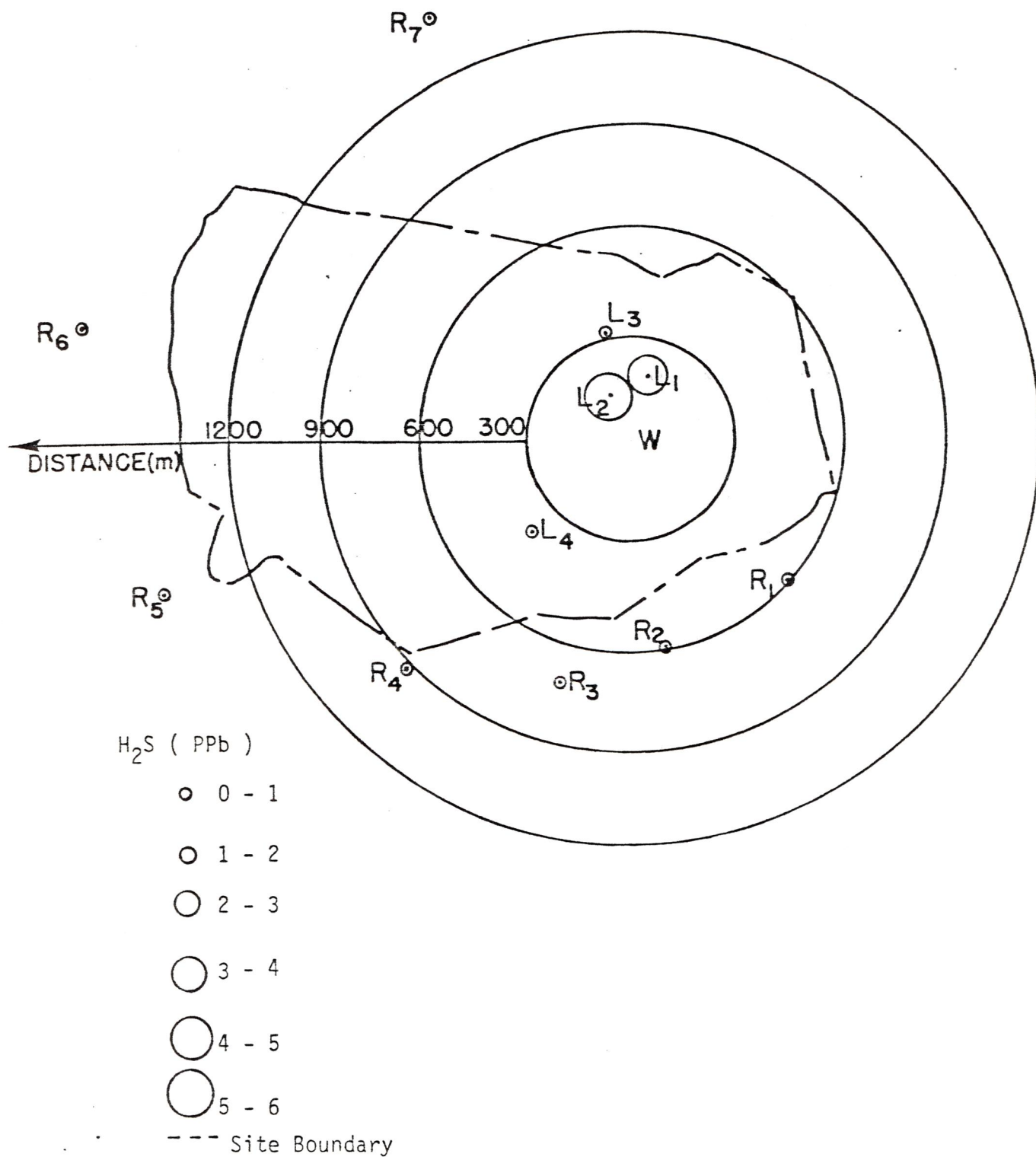
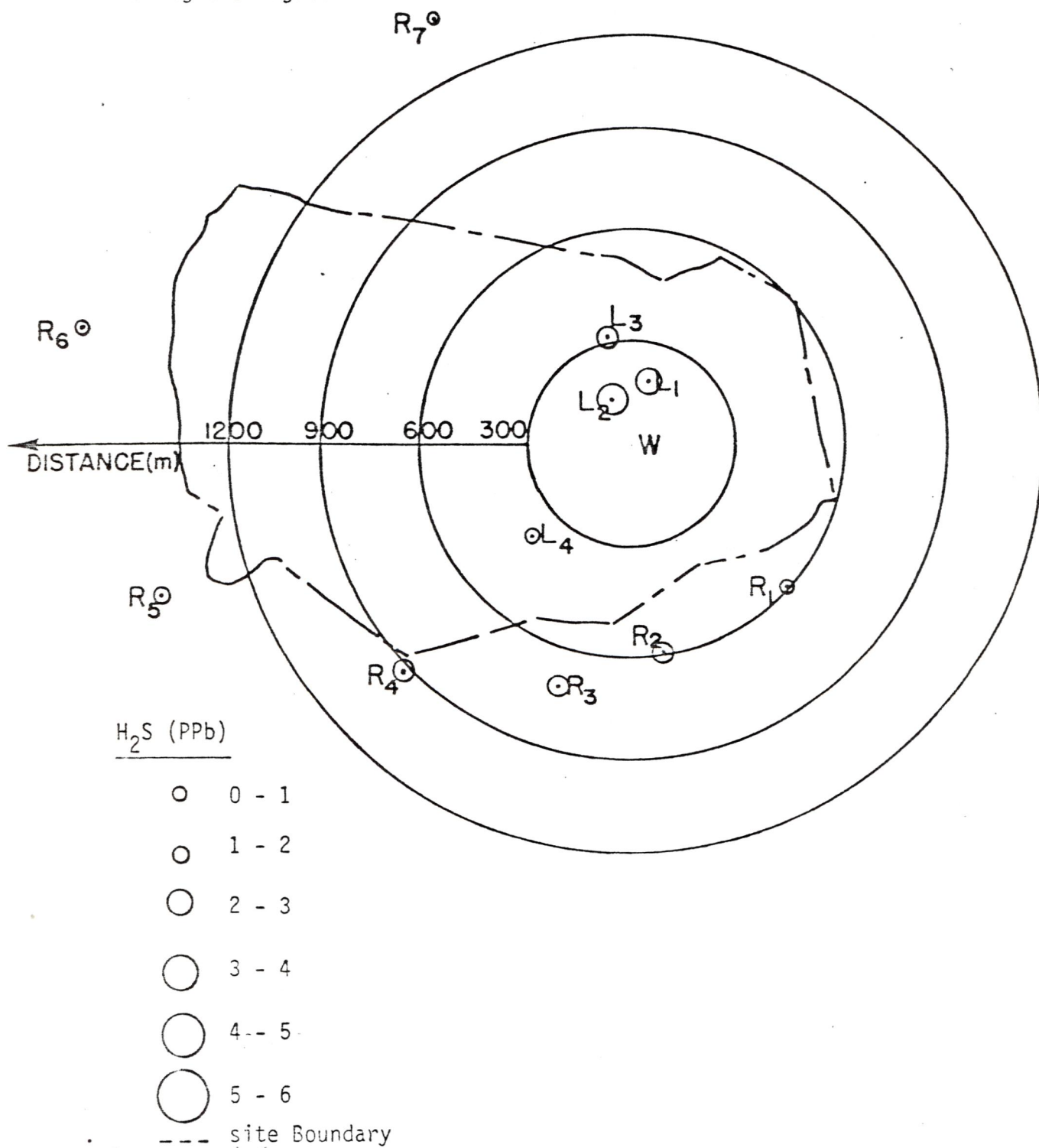


Figure 8 - Hydrogen Sulfide Concentrations in the Landfill and its Vicinity During the Night.



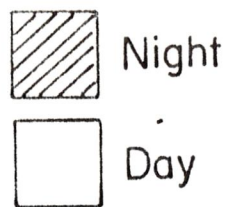
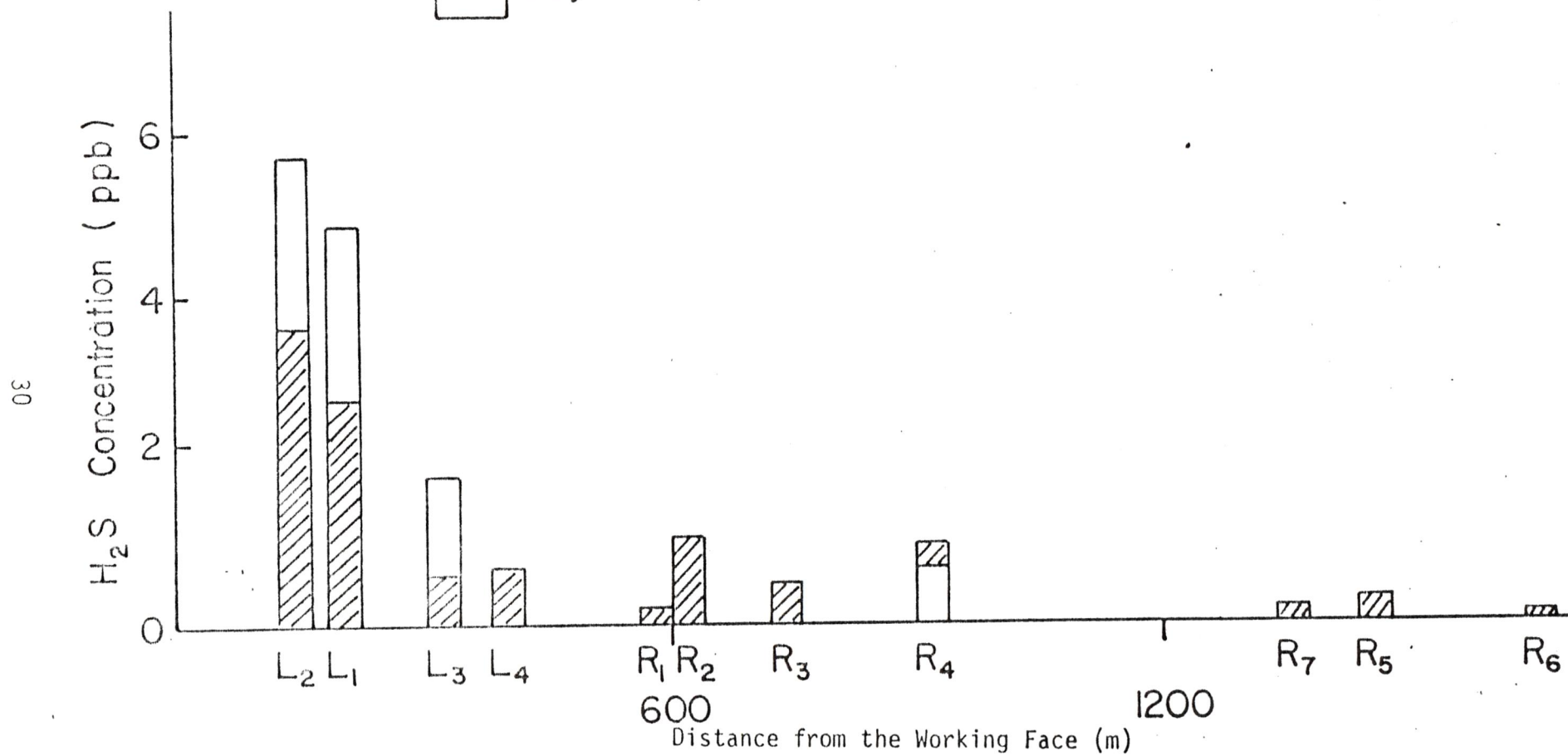


Figure 9 - Hydrogen Sulfide Variations with Distance from the Working Face.



ppm, 0.0041 mg/m<sup>3</sup>). The maximum concentration is approximately ten times lower than the State of California Ambient Air Quality Standard. It appears therefore, that there is little possibility of toxic effects; adverse effects are mainly caused by the nuisance odor characteristics of this compound.

### C. VOLATILE ORGANIC COMPOUNDS

Since this study was not guided by a predetermined list of compounds to be measured, a broad spectrum organics analysis was performed, with the goal of obtaining a wide spectrum picture of the major or minor components present. Qualitatively, the samples resemble each other greatly: they mainly consist of light hydrocarbons fairly typical to gasoline fractions; some chlorinated hydrocarbon solvents and organic silicon compounds are also present.

#### 1. GENERAL CHARACTERISTICS

No meaningful patterns were detected in the seasonal variations for samples obtained during the period December 1979 to June 1980. Figure 10 presents typical fluctuations of average benzene concentrations reported at two sampling stations within the landfill boundary. No explanation can be attached to the sudden increase in benzene concentrations during the March-April sampling. The same trend was observed for other stations for different parameters.

Table 3 lists the three major volatile organic components found in each sample.

In general it seems that the same series of major components are repeated each sampling day. However, the relative

Figure 10 - Seasonal Benzene Fluctuations At Two Typical Sampling Stations Within The Landfill Boundary.

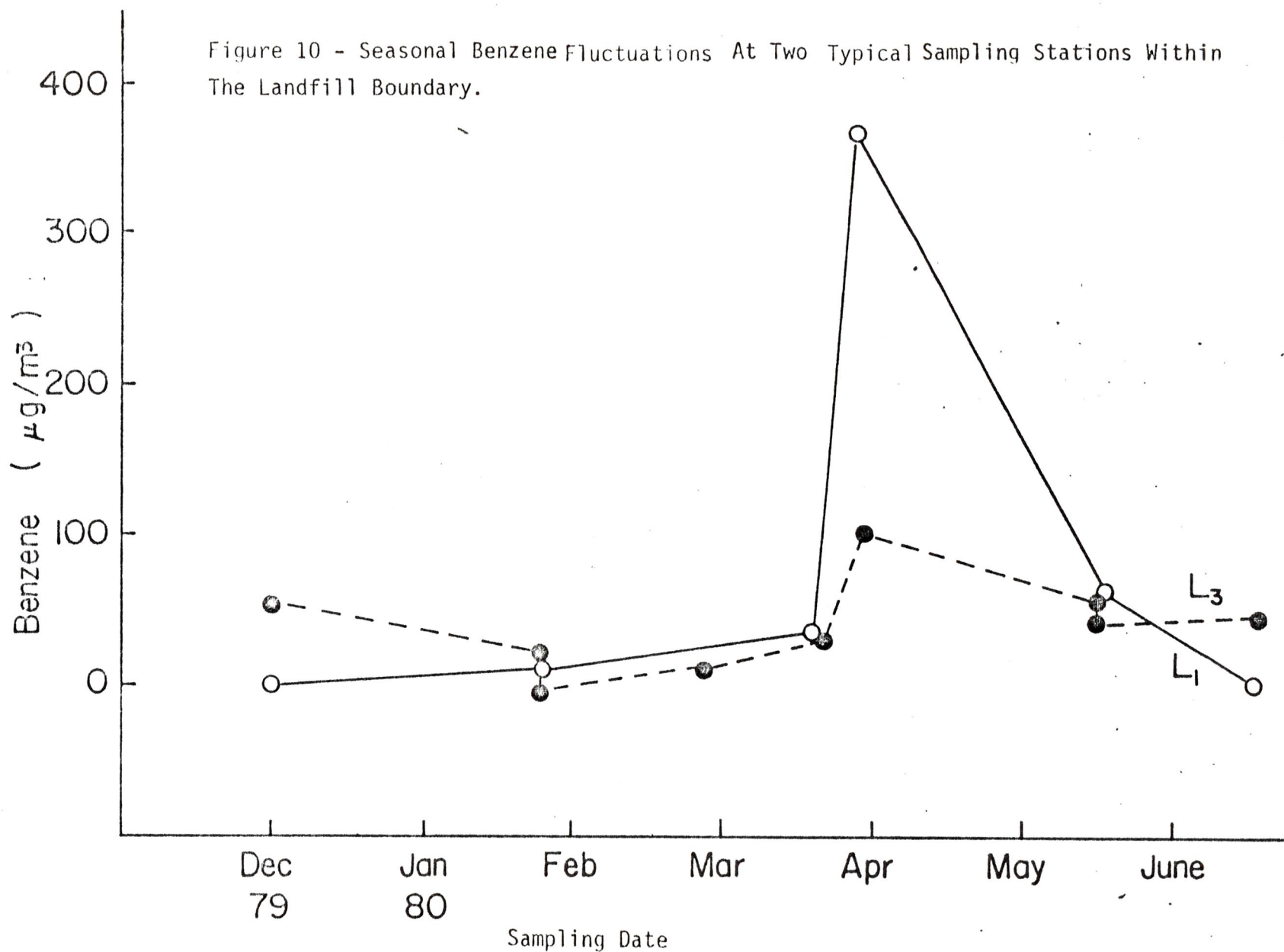


Table 3 - Three Major Volatile Organic Components Found in the Soil  
 Collected at the BKK Landfill and it's vicinity.  
 (% represents the percentage of total organics captured)

Stat.	Date	Component 1	%	Component 2	%	Component 3	%
L <sub>4</sub> -D	12/79	2 - Methyl Pentane	10	Dichlorome- thane	10	Toluene	24
W-D	12/79	2 - Methyl Pentane	20	2-3 Dimethyl Butane	13	Dimethyl Butane	14
L <sub>1</sub> -D	12/79	Hexane	21	Dichlorome- thane	22	Toluene	17
L <sub>3</sub> -D	12/79	Ketone	12	Dichlorome- thane	15	Toluene	17
L <sub>1</sub> -D	1/25/80	Hexane	50	Trichlorome- thane	11	Hexamethylcyc lotrisiloxane	13
L <sub>3</sub> -D	1/25/80	Hexane	42	Trichlorome- thane	10	Hexamethylcyc lotrisiloxane	15
L <sub>3</sub> -D	1/25/80	Penthane	9	Trichlorome- thane	39	Dichlorome- thane	23
L <sub>2</sub> -D	1/25/80	Hexane	27	Trichlorome- thane	8	Hexamethylcyc lotrisiloxane	12
L <sub>3</sub> -D	2/28/80	Hexane	38	Trichlorome- thane	13	Hexamethylcyc lotrisiloxane	12
L <sub>3</sub> -D	2/28/80	Xylene	37	Trichlorome- thane	12	Hexamethylcyc lotrisiloxane	13
L <sub>2</sub> -D	3/7/80	Hexane	23	Toluene	17	Hexamethylcyc lotrisiloxane	16
L <sub>2</sub> -D	3/7/80	Xylene	30	Toluene	21	Ethylbenzene	4
R <sub>6</sub> -D	3/8/80	Xylene	33	Hexane	13	Hexamethylcyc lotrisiloxane	9
R <sub>4</sub> -N	3/21/80	Xylene	40	Toluene	26	Ethylbenzene	8

Table 5 - (continued)

Stat.	Date	Component 1	%	Component 2	%	Component 3	%
L <sub>1</sub> -D	3/21/80	Benzene	17	Methylene-Chloride	11	Hexamethylcyclotrisiloxane	19
L <sub>3</sub> -D	3/21/80	Benzene	2	Toluene	2	Hexamethylcyclotrisiloxane	37
R <sub>1</sub> -N	3/21/80	Benzene	5	Dimethyl-Benzene	2	Hexamethylcyclotrisiloxane	77
R <sub>2</sub> -N	3/21/80	Xylene	5	Toluene	5	Hexamethylcyclotrisiloxane	
R <sub>3</sub> -N	3/21/80	Benzene	5	Dimethyl-Benzene	7	Hexamethylcyclotrisiloxane	65
R <sub>2</sub> -N	3/28/80	Toluene	9	Dimethyl-Benzene	8	Hexamethylcyclotrisiloxane	21
R <sub>3</sub> -N	3/28/80	Toluene	4	Chlorobenzene	7	Hexamethylcyclotrisiloxane	58
R <sub>4</sub> -N	3/28/80	Benzene	7	Xylene	34	Hexamethylcyclotrisiloxane	23
L <sub>1</sub> -N	3/28/80	Octane	7	Toluene	9	Hexamethylcyclotrisiloxane	22
L <sub>3</sub> -D	3/28/80	Benzene	6	Toluene	12	Hexamethylcyclotrisiloxane	52
R <sub>4</sub> -N	3/28/80	Xylene	17	Toluene	11	Dichloromethane	24

Stat.	Date	Component 1	%	Component 2	%	Component 3	%
L <sub>3</sub> -N	5/14/80	Dichloromethane	19	Carbon Disulfide	6	Octamethyl	33
L <sub>4</sub> -N	5/14/80	Siloxane	40	Toluene	11	Xylene	11
L <sub>1</sub> -N	5/14/80	Dichloromethane	67	Toluene	31	Benzene	9
L <sub>1</sub> *-N	5/14/80	Dichloromethane	12	Toluene	17	Xylene	20
L <sub>1</sub> *-N	5/14/80	Dichloromethane	37	Acetone	9	Hexamethylcyclotrisiloxane	20
R <sub>7</sub> -N	5/14/80	Dichloromethane	11	Ethyl Benzene	9	Xylene	35
R <sub>1</sub> -N	5/14/80	Dichloromethane	36	Ethyl Benzene	7	Xylene	9
R <sub>2</sub> -N	5/14/80	Dichloromethane	24	Pentane	9	Hexane	9

Stat.	Date	Component 1	%	Component 2	%	Component 3	%
L <sub>2</sub> -D	5/17/80	Dichloromethane	9	Toluene	14	Xylene	19
L <sub>1</sub> -D	5/17/80	Dichloromethane	11	Hydrocarbon	14	Acetic acid	27
L <sub>3</sub> -D	5/17/80	Dichloromethane	10	Octane	14	Hexamethylcyclotrisiloxane	20
L <sub>4</sub> -D	5/17/80	Dichloromethane	10	Toluene	14	Hexamethylcyclotrisiloxane	20
L <sub>1</sub> <sup>*</sup> -D	5/17/80	Dichloromethane	14	Xylene	15	Ethylbenzene	14
L <sub>1</sub> <sup>**</sup> -D	5/17/80	Methylcyclopentane	17	Toluene	20	Hexamethylcyclotrisiloxane	8
R <sub>7</sub> -D	5/17/80	Chloromethane	19	Toluene	20	Hexamethylcyclotrisiloxane	15
R <sub>1</sub> -D	5/17/80	Tetramethyl Butane	17	Toluene	17	Xylene	14
R <sub>2</sub> -D	5/17/80	Siloxane	52	Toluene	7	Hexamethylcyclotrisiloxane	9
R <sub>4</sub> -D	5/17/80	Dichloromethane	23	Toluene	12	Xylene	15
L <sub>2</sub> -N	5/17/80	Dichloromethane	37	Freon	18	Siloxane	9
L <sub>1</sub> -N	5/17/80	Dichloromethane	42	Toluene	9	Acetone	12
W <sub>0</sub> -D	6/17/80	Toluene	21	Xylene	13	Hexane	7
L <sub>2</sub> -D	6/17/80	Toluene	11	Hydrocarbon	11	Hexane	6
L <sub>3</sub> -D	6/17/80	Toluene	29	Benzene	7	Hexane	9
L <sub>1</sub> -D	6/17/80	Toluene	7	Heptane	7	Hexane 2, 2, 6-Trimethyl	52
W <sub>6</sub> -D	6/17/80	Toluene	10	Hexane	10	Octane 3, 1 - Methyl	45
R <sub>1</sub> -D	6/17/80	Toluene	27	Benzene	5	Xylene	28
R <sub>2</sub> -D	6/17/80	Ethyl Benzene	19	Benzene	7	Xylene	20

percentage of these major components varies depending on the location of the sampling stations. This probably is related to the degree of volatility of the compounds, permitting some chemicals to be present at longer distances from the source.

Figure 11 compares total average concentration of organic compounds at the landfill and its adjacent residential area. Sampling stations  $R_4$  does not follow the general trend of positive correlation between concentrations and proximity to the working face. A reasonable explanation for these deviations is the dominant SSW wind direction;  $R_4$  is located downwind. This trend was experienced for other parameters. A similar explanation may apply to  $R_2$  concentrations, always higher than those for  $R_1$  although both of these stations are located in a similar distance from the working face.

Figures 12 and 13, show the average distribution of volatile organic compounds within the landfill and in its vicinity. Here again we find the same trend observed previously: high concentrations of volatile organic compound during the day close to the working face, while the residential area shows relatively lower concentrations. Relatively lower organics concentration near the working face at night, while the residential area shows relatively higher concentrations. Total volatile organics concentrations, showed a wide range of values, covering from  $30 \mu\text{g}/\text{m}^3$  to  $9000 \mu\text{g}/\text{m}^3$ . The average concentration observed was  $1300 \mu\text{g}/\text{m}^3$ ; this value is higher than the Federal (and State of California) standard of  $160 \mu\text{g}/\text{m}^3$  (0.24 ppm), as methane, averaged over three

Figure 11 - Average Volatile Organic Concentration in the Landfill and its Vicinity.

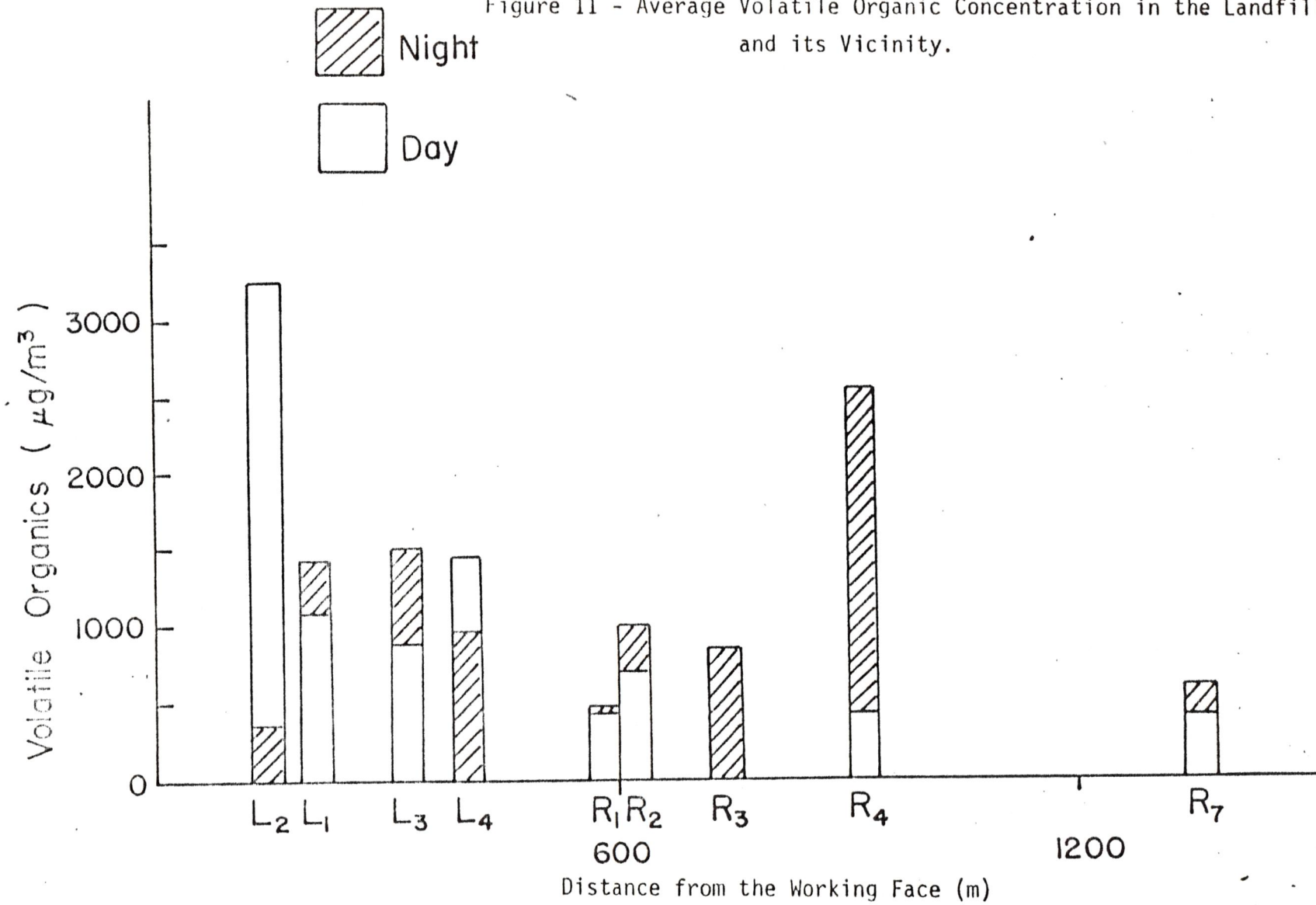


Figure 12. Average Volatile Organics Distribution during the day.

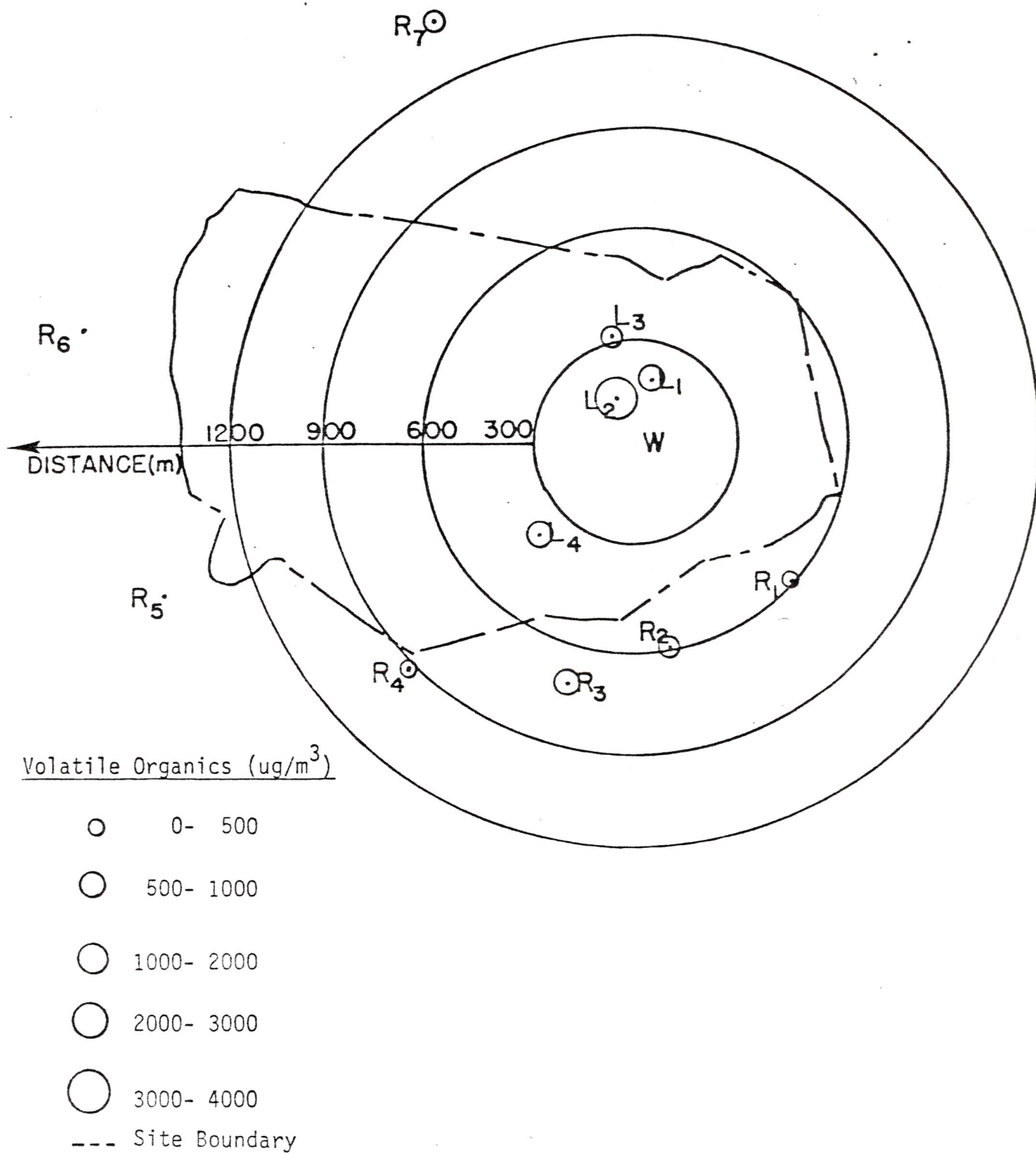
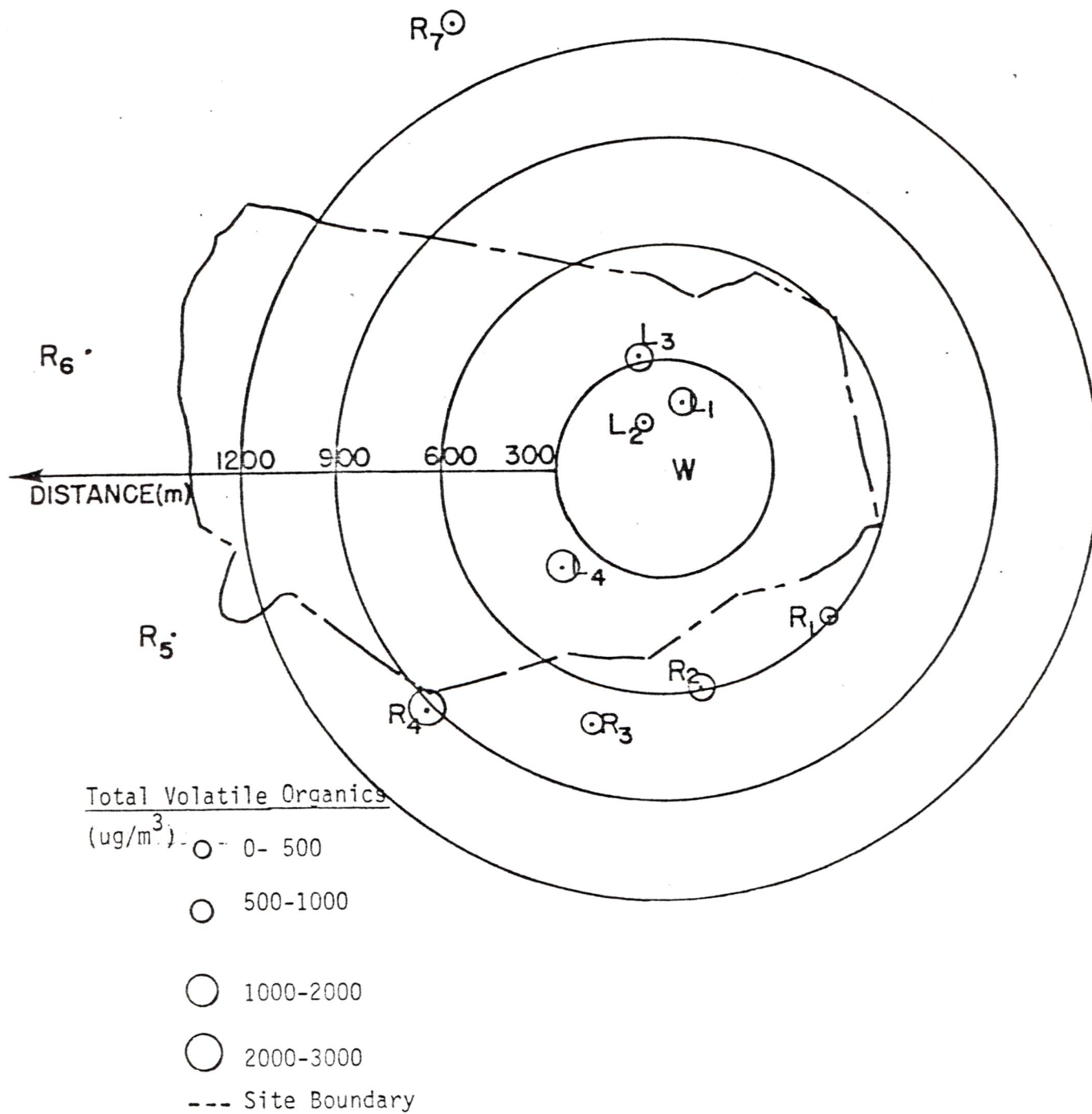


Figure 13 - Average Volatile Organics Distribution During the Night



Memo: Second Interim Report - Investigation  
of Odorous & Volatile Compounds for  
BRL Glass I Landfill

To: Rod Cummings

From: Bob Jackson

Special

The interim report is a study of odorous  
substances & volatile organic compounds at  
the BRL Glass I landfill. The study  
concludes that the pattern of BRL is mostly  
attributed to natural (odor) and anthropogenic  
sources of odor. Also existing of emitting  
gas from the sulfuric acid wells, ammonia  
trayor series of odor emissions.

Specific emissions were measured at  
an unmonitored well:

Compared  
Measured  
Concentration  
H2S/TLV  
over 6 hrs

H<sub>2</sub>S

0 - 575 ppb

10,000 ppb

Chloroform

Based  
Detection - 190 ug/m<sup>3</sup>  
(3-14 ug/m<sup>3</sup> @ 1500 ft)  
240,000 ug/m<sup>3</sup> (NIOSH)



Cheminated organics were measured at  
concentrations of 0.1 to 0.7 mg/m<sup>3</sup>.  
There are no U.S. ambient standards  
to compare these levels with.  
The report does not evaluate or  
mention the integrity of the site  
as it would relate to any other  
situation in a Class I landscape.  
The only apparent objective was  
to define the odor problems at the  
site.

BELOW DETECTION - 3.4 ug/m<sup>3</sup> 80,000 ug/m<sup>3</sup>  
REUSE

hours (6-9am). However, with the exception of carcinogens, covered in the next section, hydrocarbons are generally inert (non-toxic). Their adverse effects consist mainly in the generation of smog, after photochemical reaction with nitrogen oxides. However, these concentrations could possibly be decreased by more frequent covering of liquid industrial wastes with layers of soil, which has highly adsorptive properties. In most cases, high concentrations of hydrocarbons are only detected within the landfill. Nevertheless, it is one identifiable source of emission that should be controlled.

## 2. CARCINOGENS

One of the major concerns in studying the composition of volatile organic compounds is the presence of compounds identified as possible carcinogens.

The Occupational Safety and Health Administration (OSHA) has proposed a comprehensive policy in regulating human exposures to potential carcinogens. Under the proposed policy a substance (depending upon its carcinogenicity) is put into one of four categories:

Category I - confirmed carcinogens. Substances found to be carcinogenic in humans or in two mammalian species of test animals, or in one species if the same results were obtained by more than one series of experiments.

Category II - suspected carcinogens. Evidence of carcinogenicity is suggestive or it positive in one species of test animals.

Category III - those substances which require further research. No regulatory action necessary.

Category IV - those substances which are not currently found in the American workplace. No regulatory action necessary.

Among the organics identified by GC/MS analysis, two compounds are included in Category I carcinogens: chloroform and benzene.

### a. Chloroform

Chloroform ( $\text{CHCl}_3$ ) is in liquid form at normal ambient temperatures and pressures. Its boiling point is low, resulting in a high vapor pressure, which is responsible for its movement into the atmosphere. Its specific gravity is greater than that of air because of higher molecular weight than that of nitrogen/oxygen, the principal air constituents. This property is of interest since it is responsible for settling of the vapors on the lower levels of the atmosphere, greatly delaying complete mixing.

In the continental United States, typical dispersive uses of chloroform are largely in a variety of pharmaceutical formulation processes. Liquid industrial wastes are most likely an important source of chloroform at the BKK Landfill.

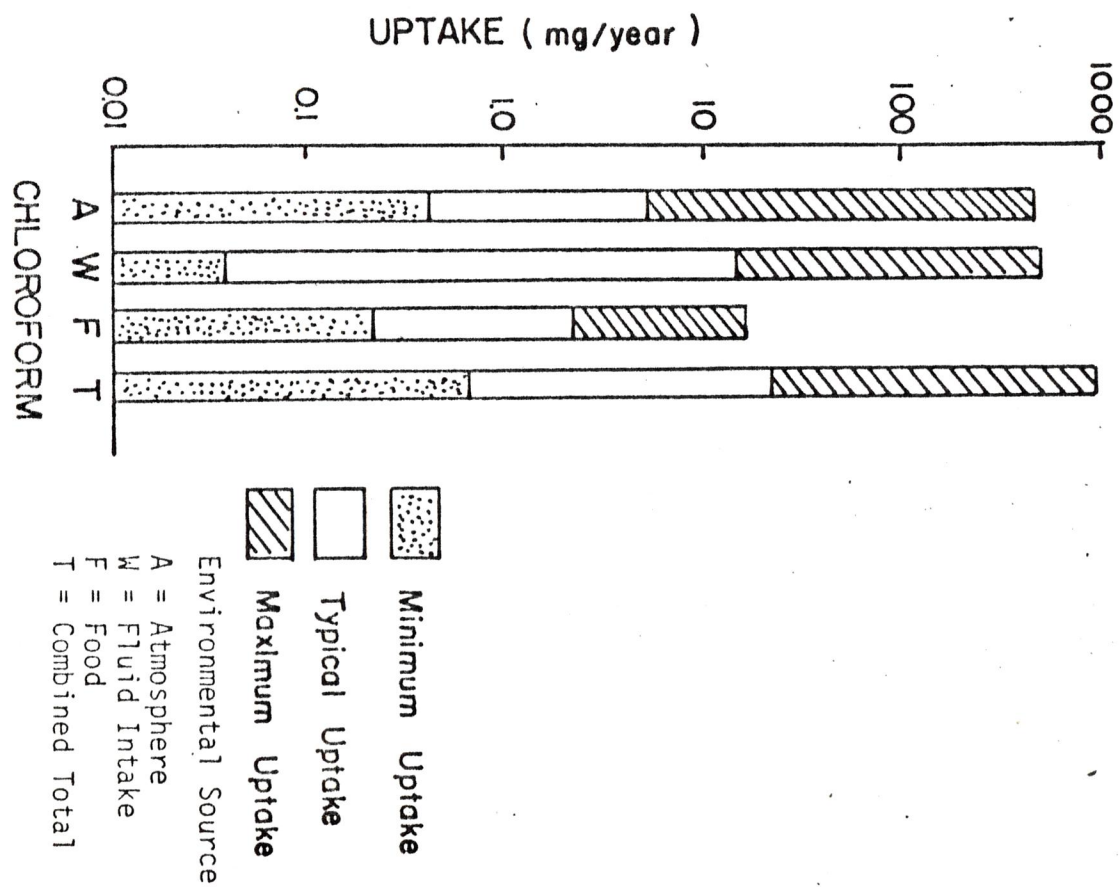
Relative uptake of chloroform by adult man from fluid intake, atmosphere, and food supply is depicted in Figure 14 (from reference 9). Overall, the typical uptake is averaged at 8.4 mg/year. When this is compared with an average respiratory volume for adult man of 8400 m<sup>3</sup> of air breathed per year (Table 4, from reference 14), one obtains the average atmospheric concentration of chloroform providing the same exposure as typical overall uptake, namely 1ug/m<sup>3</sup>.

TABLE 4 REspiratory Volumes for Reference Man  
(in liters of air breathed) (from Reference 14)

	Adult Man	Adult Woman	Child (10yr)	Infant (1yr)
8-hr Working Light Activity	9,600	9,100	6,240	2,500(10-hr)
8-hr Nonoccupational Activity	9,600	9,100	6,240	
8-hr Resting	3,600	2,900	2,300	1,300(14hr)
Total (liter/day)	2.3×10 <sup>4</sup>	2.1×10 <sup>4</sup>	1.5×10 <sup>4</sup>	0.38×10 <sup>4</sup>
Total (liter/year)	8.4×10 <sup>6</sup>	7.7×10 <sup>6</sup>	5.5×10 <sup>6</sup>	1.4×10 <sup>6</sup>

The range of atmospheric concentrations of chloroform measured at the BKK landfill was found to range from less than 1 ug/m<sup>3</sup> (the detection limit) to 60 ug/m<sup>3</sup> with an average of 15 ug/m<sup>3</sup>. These concentrations were

Figure 14 - Relative Uptake of Chloroform by Adult Man from Fluid Intake, Atmosphere, and food Supply ( $\mu\text{g}/\text{year}$ ).



experienced during the day; at night only two stations were found to exceed slightly the detection limit of  $1 \text{ ug/m}^3$  (Figures 15 to 17). The average concentration of chloroform observed is higher than the typical overall exposure of  $1 \text{ ug/m}^3$  mentioned above, but is much lower than the permissible occupational level of  $50 \text{ mg/m}^3$  (10 ppm) averaged over an 8-hour work day) stated by the National Institute for Occupational Safety and Health (NIOSH) 9, 10.

Figures 15 and 16 compare chloroform concentrations measured at the sampling stations during day-and night-time. As these figures point out, higher chloroform concentrations were observed only close to the working face, during the day.

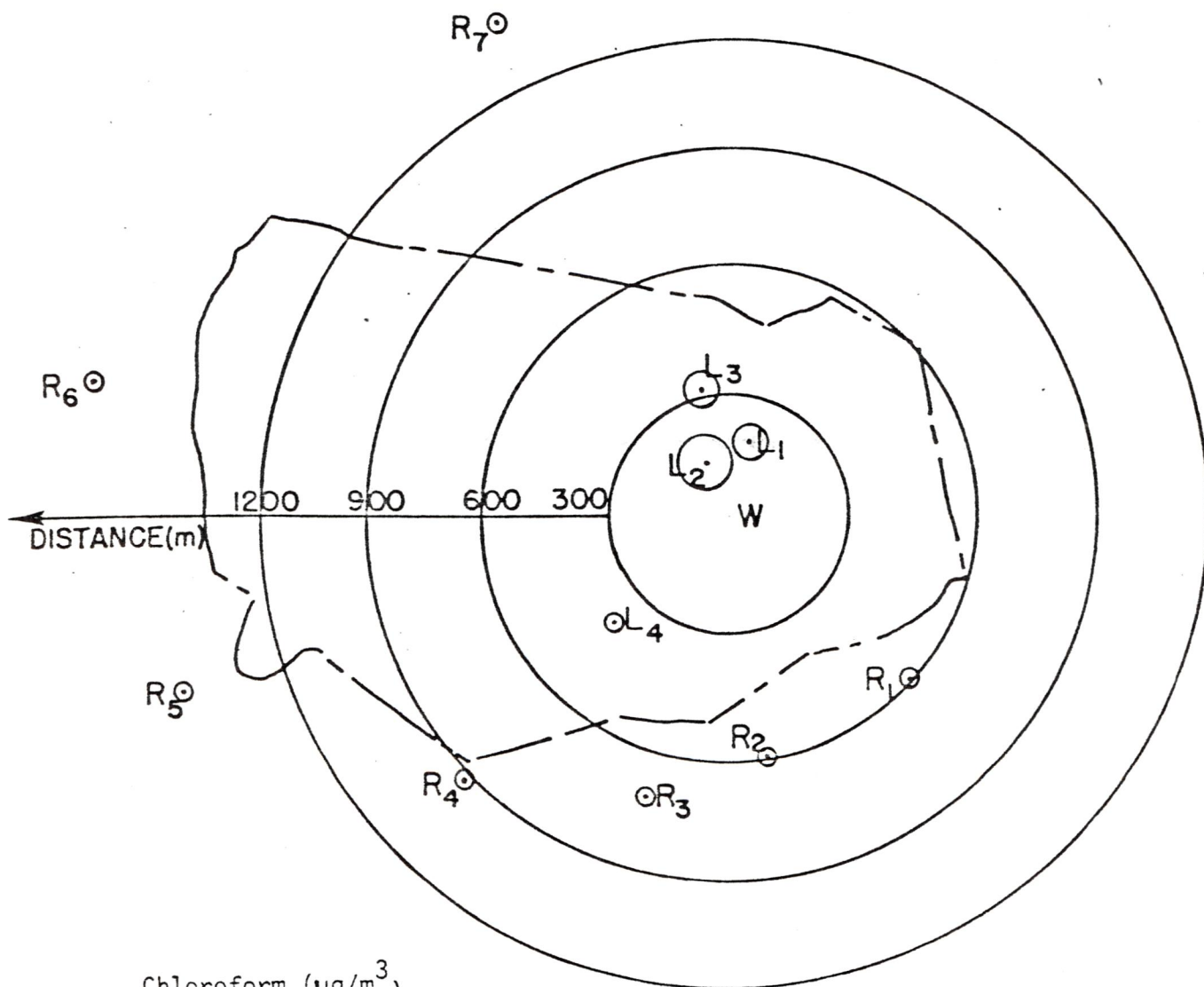
Figure 17 shows some positive correlation between chloroform concentration and proximity to the working face.

#### b. Benzene

Benzene is a clear colorless liquid with a relative low boiling point of  $80^\circ\text{C}$ , and a high vapor pressure of 100 mm at  $26.1^\circ\text{C}$ . It is an irritant toxic, if the vapor is inhaled. OSHA has issued a standard of 1ppm ( $3.2 \text{ mg/m}^3$ ) averaged over an 8-hour work day. This standard is presently stayed by the courts. Chronic benzene poisoning affect, blood-forming cells, leading to leukemia.

Figures 18 and 19 show the range of total carcinogens (benzene, chloroform) measured at the landfill and their distribution. No clearcut difference was observed for day-time or night-time readings, possibly due to the high volatility of benzene.

Figure 15 - Average Chloroform Concentrations During The Day-Time



Chloroform ( $\mu\text{g}/\text{m}^3$ )

- Below Detection Limit
- 1 - 5
- 5 - 50
- > 50
- Site Boundary

Figure. 16 Average Chloroform Concentrations During the Night Time.

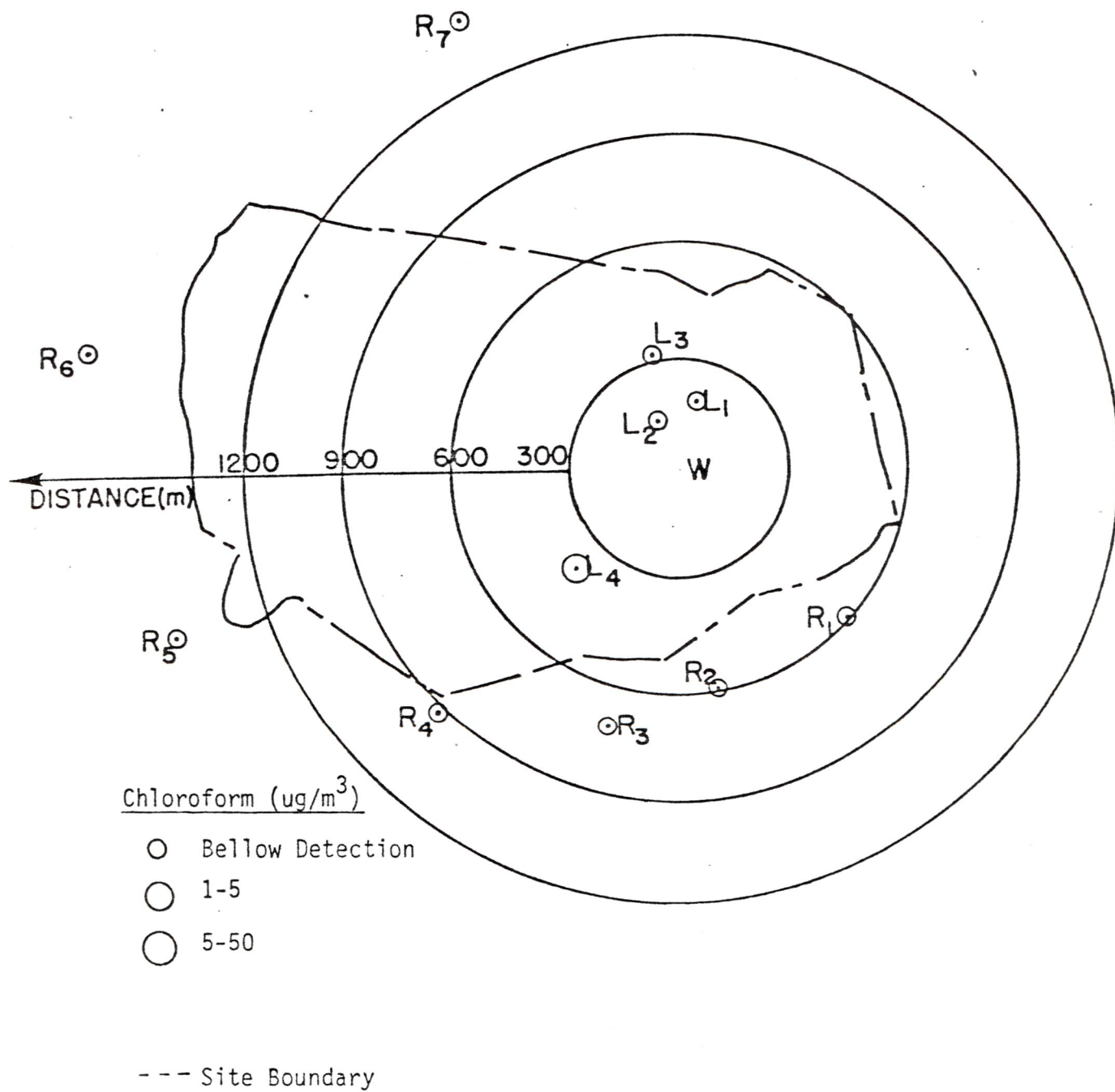


Figure 17 Chloroform Distribution Correlated to the Distance from the Working Face.



Night



Day



Below Detection Limit.

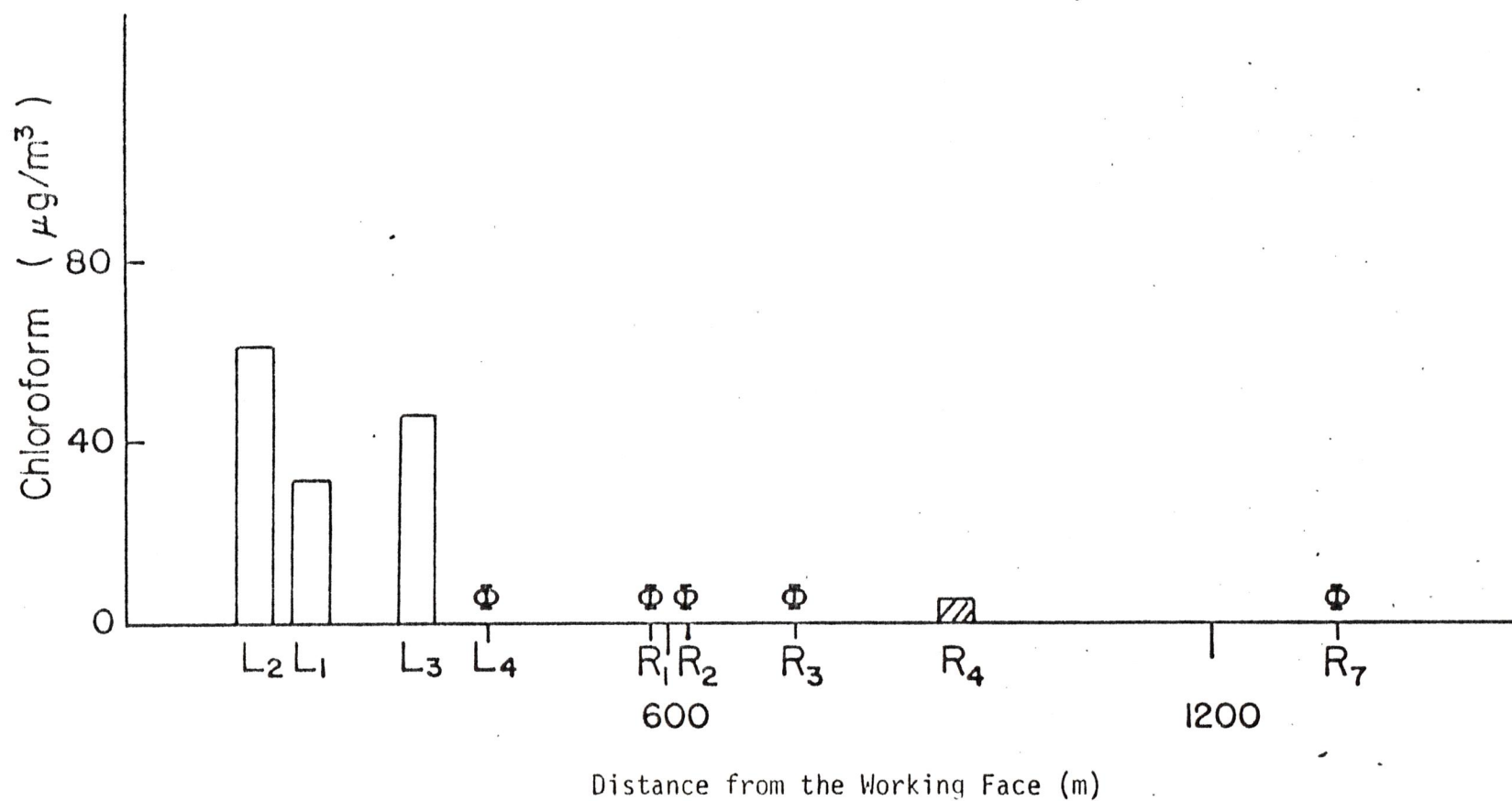
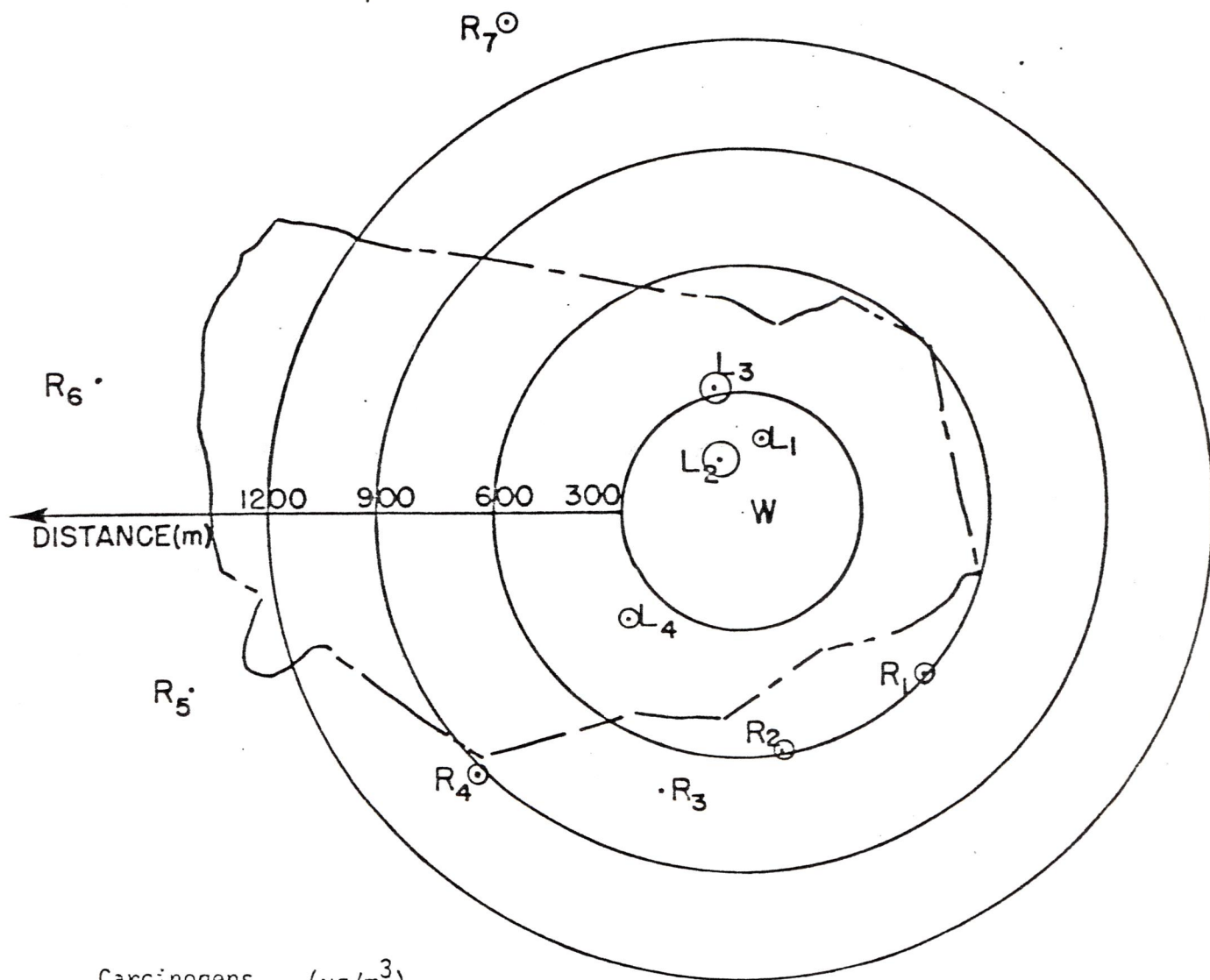


Figure 18 - Total Carcinogens (Category I) Distribution During The Day



Carcinogens	( $\mu\text{g}/\text{m}^3$ )
○	0-50
○	50-100
○	100-150
---	Site boundary

Figure 19 - Total Carcinogens (Category I) Distribution During The Night

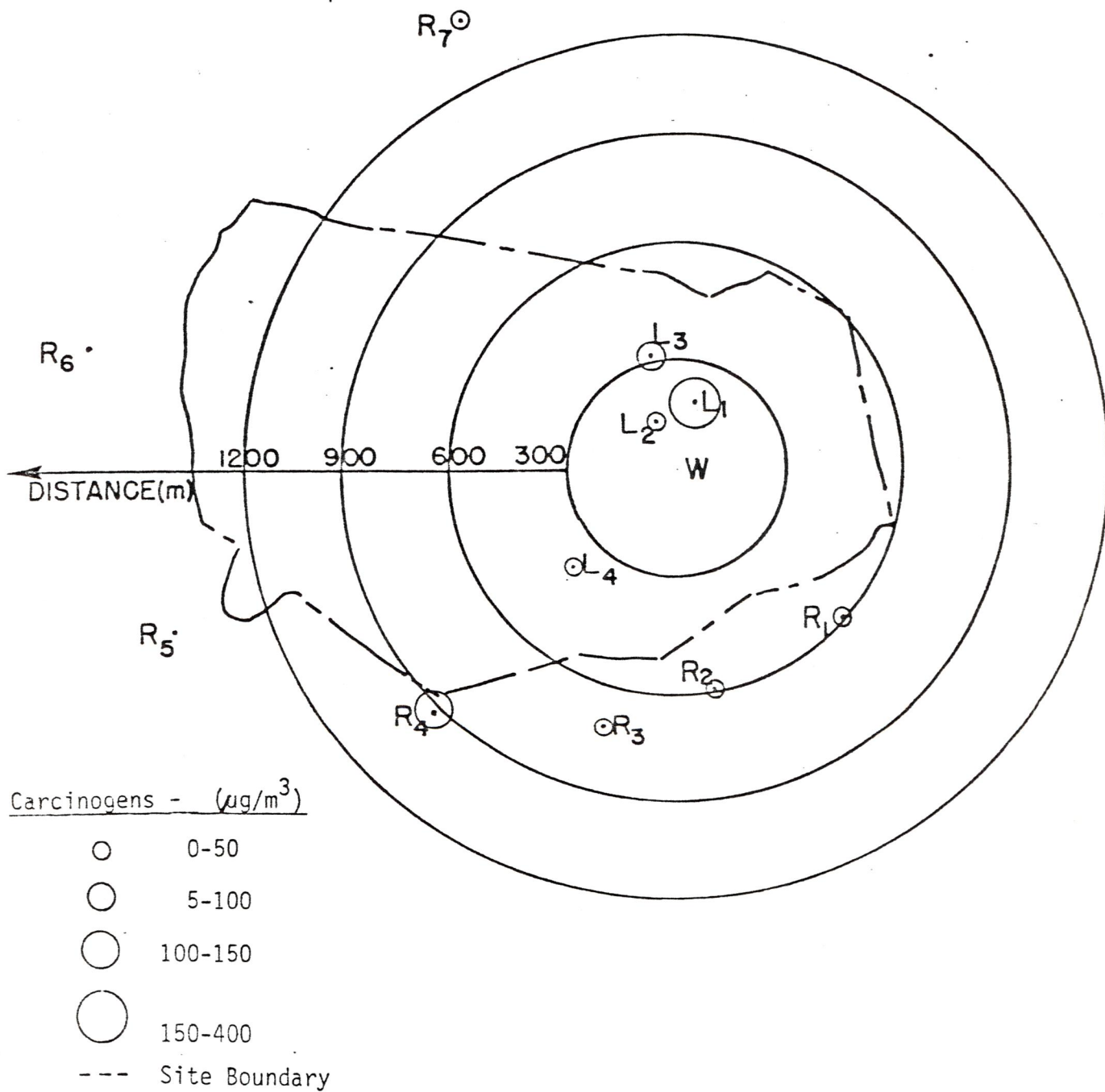


Figure 20 indicates some positive correlation between Carcinogens concentrations and proximity to the working face.

The concentrations of benzene in all the samples analyzed ranged from below detection limit in the adjacent residential area to a maximum of  $364 \text{ ug/m}^3$  ( $0.364 \text{ mg/m}^3$ ) around the disposal area. The highest concentration is far below the OSHA standard of  $3.2 \text{ mg/m}^3$  mentioned above.

Figure 21 shows the correlation between carcinogens (chloroform and benzene) concentrations, and total volatile organics concentrations. The fairly positive correlation between these two sets of data supports the assumption that the carcinogens are part of the volatile organics disposed at BKK, and that their concentration is proportional to the total amount of organics.

This correlation may imply that the carcinogen present at the landfill may only be eliminated by strict source control or stringent disposal practice.

### 3. CHLORINATED ORGANIC COMPOUNDS

Compounds containing carbon and chlorine or carbon, oxygen and chlorine, or carbon, hydrogen, oxygen, and chlorine, are classified as chlorinated organic compounds. These compounds should be taken into consideration because recent investigations indicate that a major portion of these compounds are suspected to be hazardous to human health, chlorinated organics may act toxicant to wildlife, and serve as initiators of secondary air pollutants. However, no U.S. ambient standards have been proposed for these compounds and

Figure 20 - Total Carcinogens Variations With The Distance From The Working Face

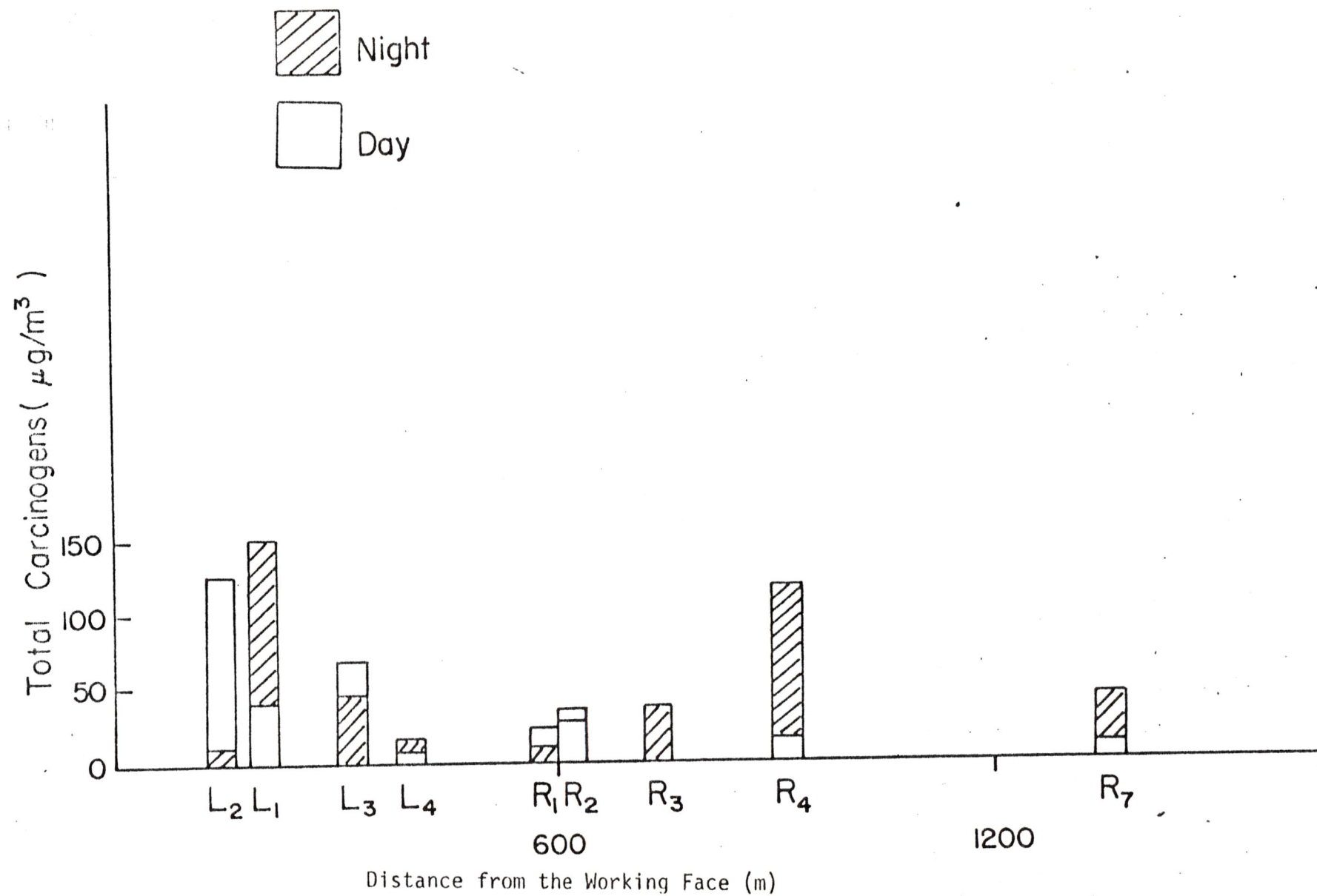


Figure - 21 Correlation Between Concentrations of Volatile Organics and Carcinogens.

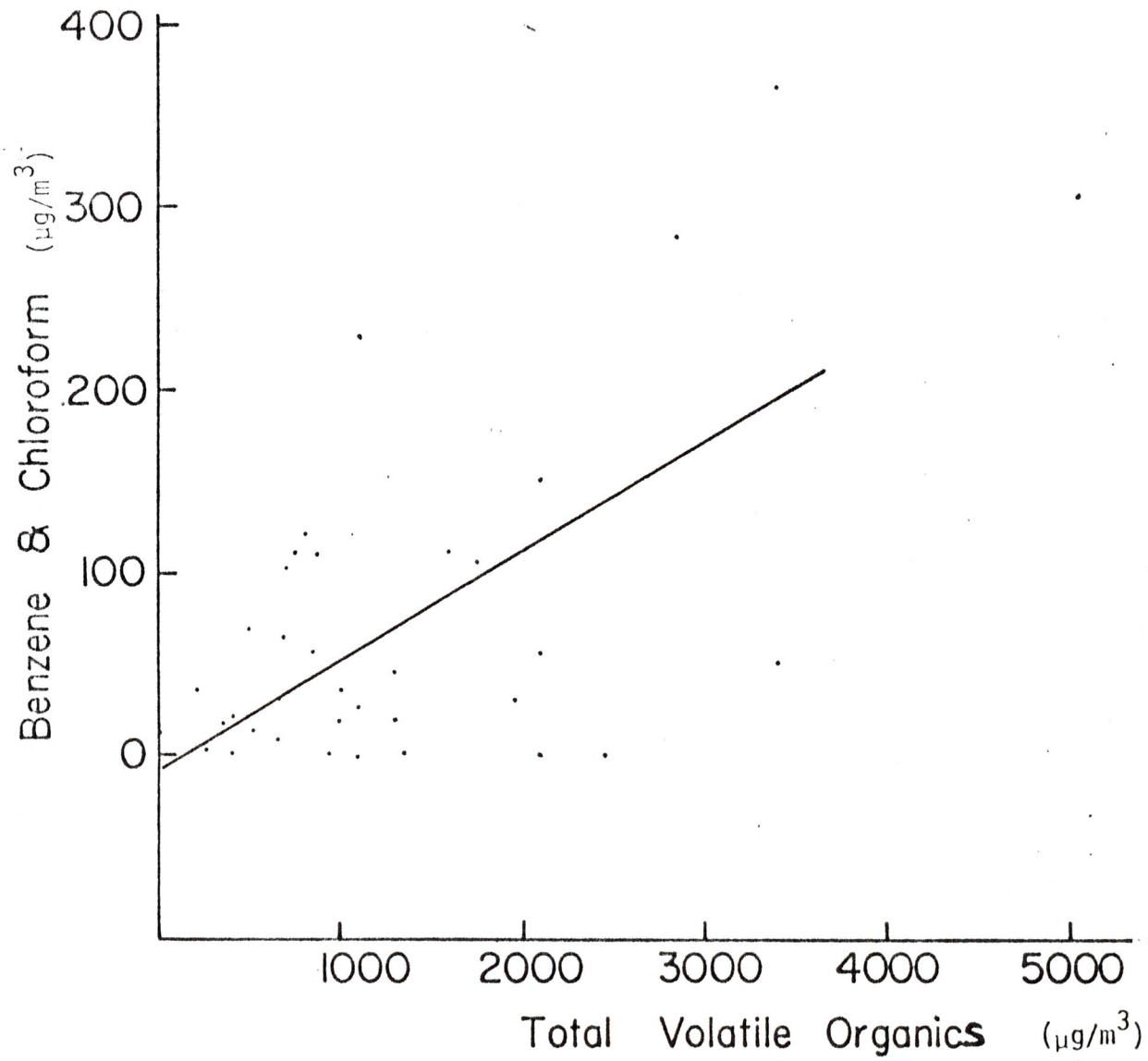
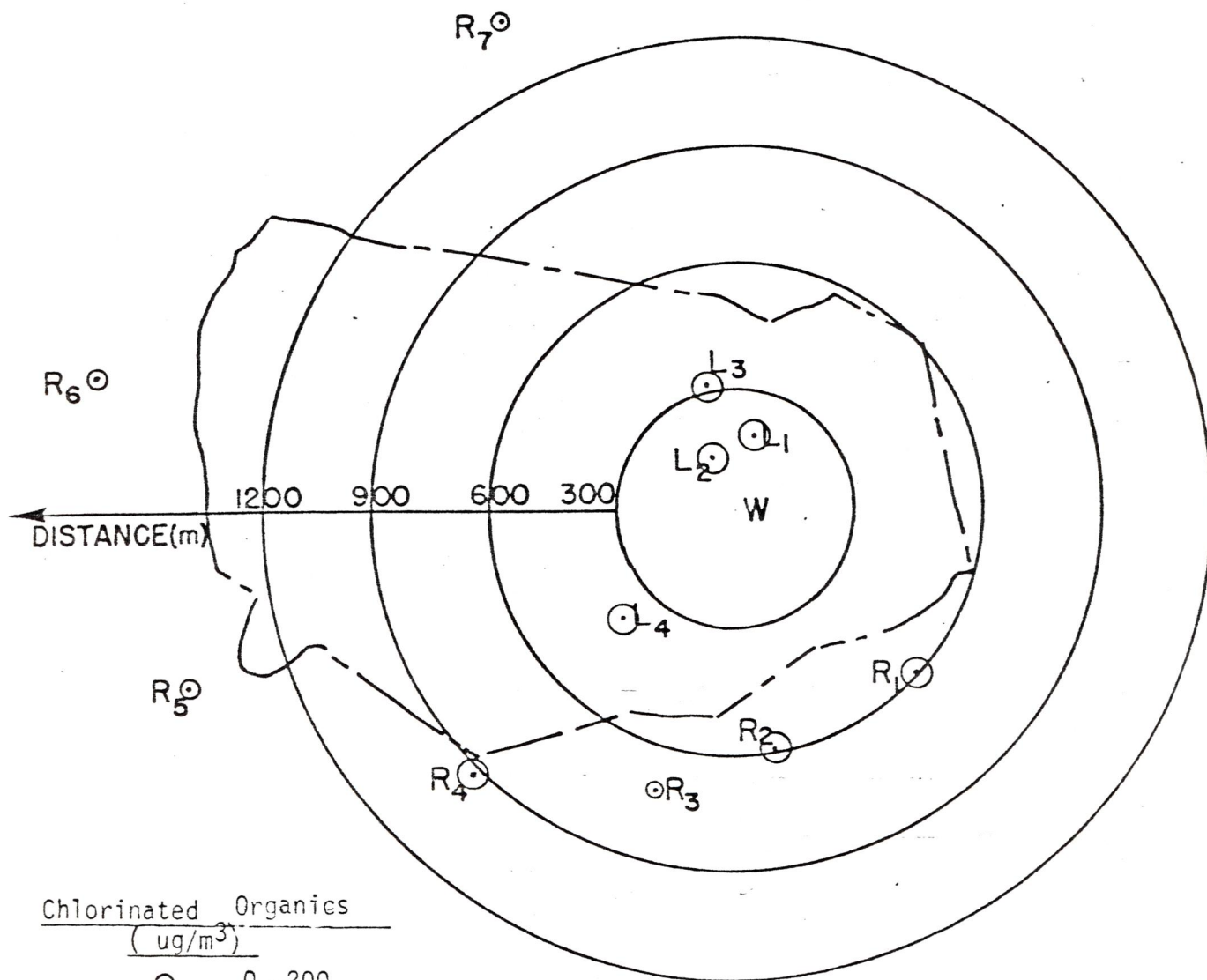


Figure 22 - Chlorinated Organics Distribution During The Day



Chlorinated Organics  
( $\mu\text{g}/\text{m}^3$ )

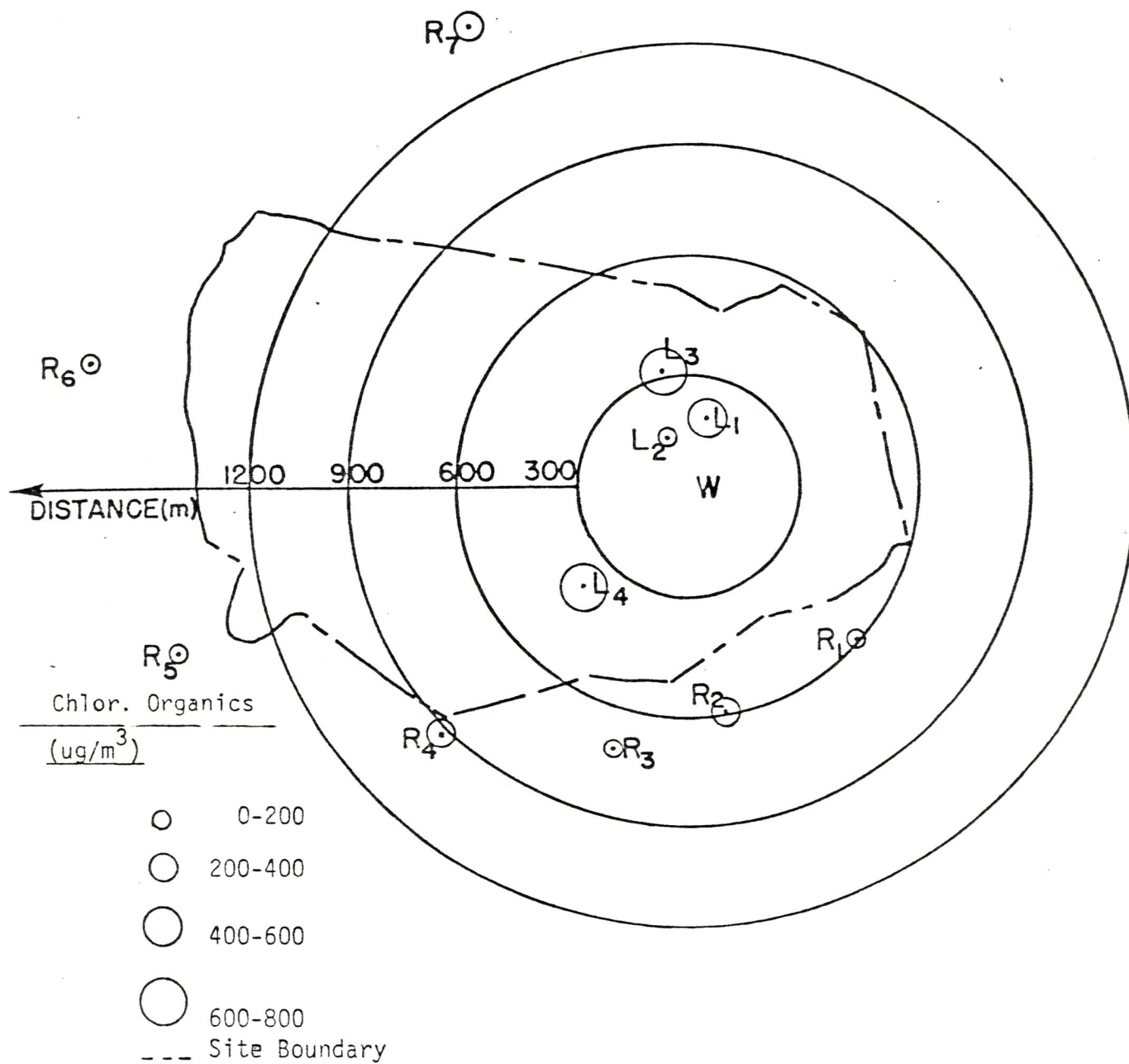
○ 0 - 200

○ 200 - 400

○ 400 - 600

--- Site Boundary

figure 23 - Chlorinated Organics Distribution during the Night.



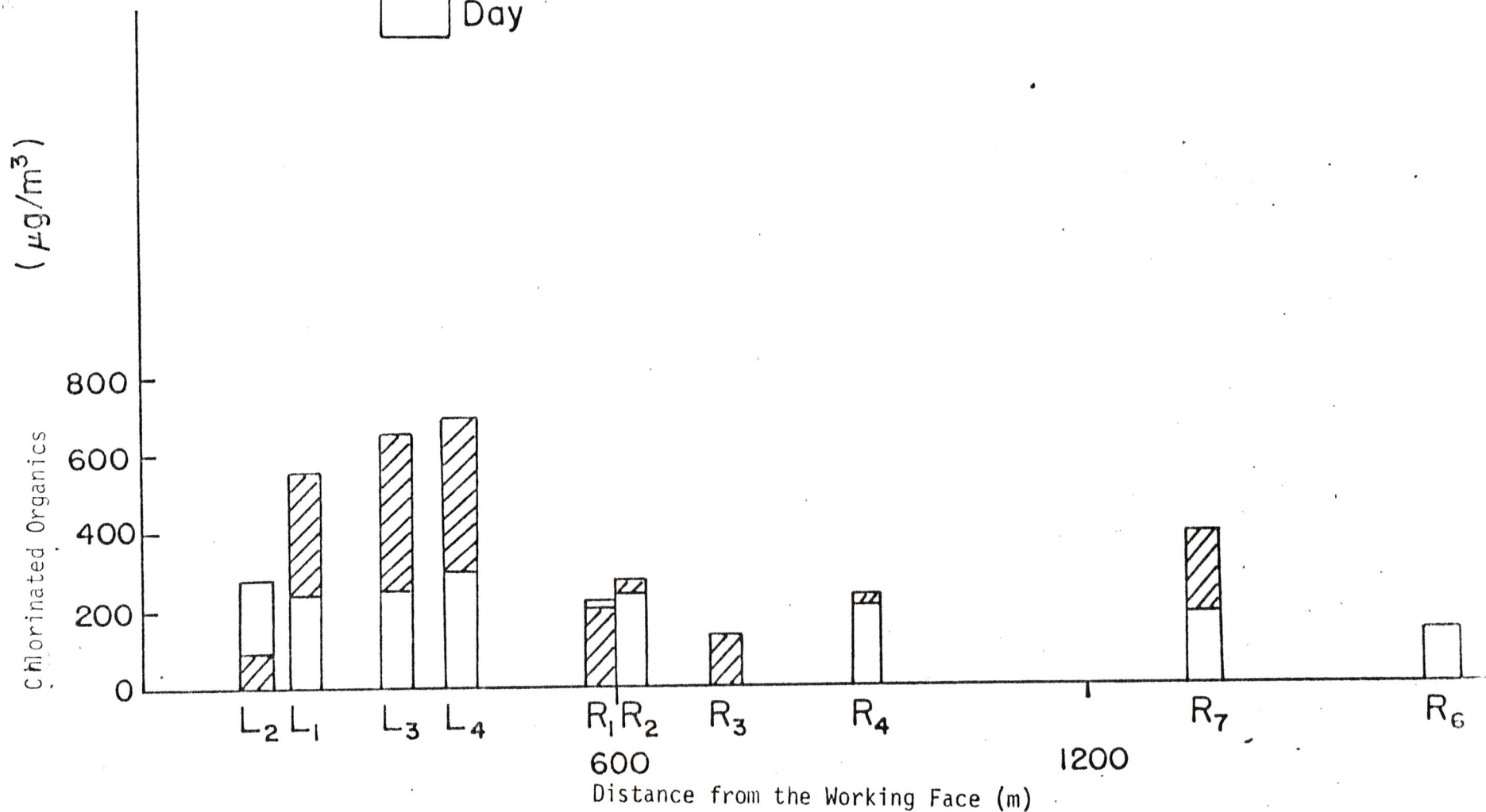


Night



Day

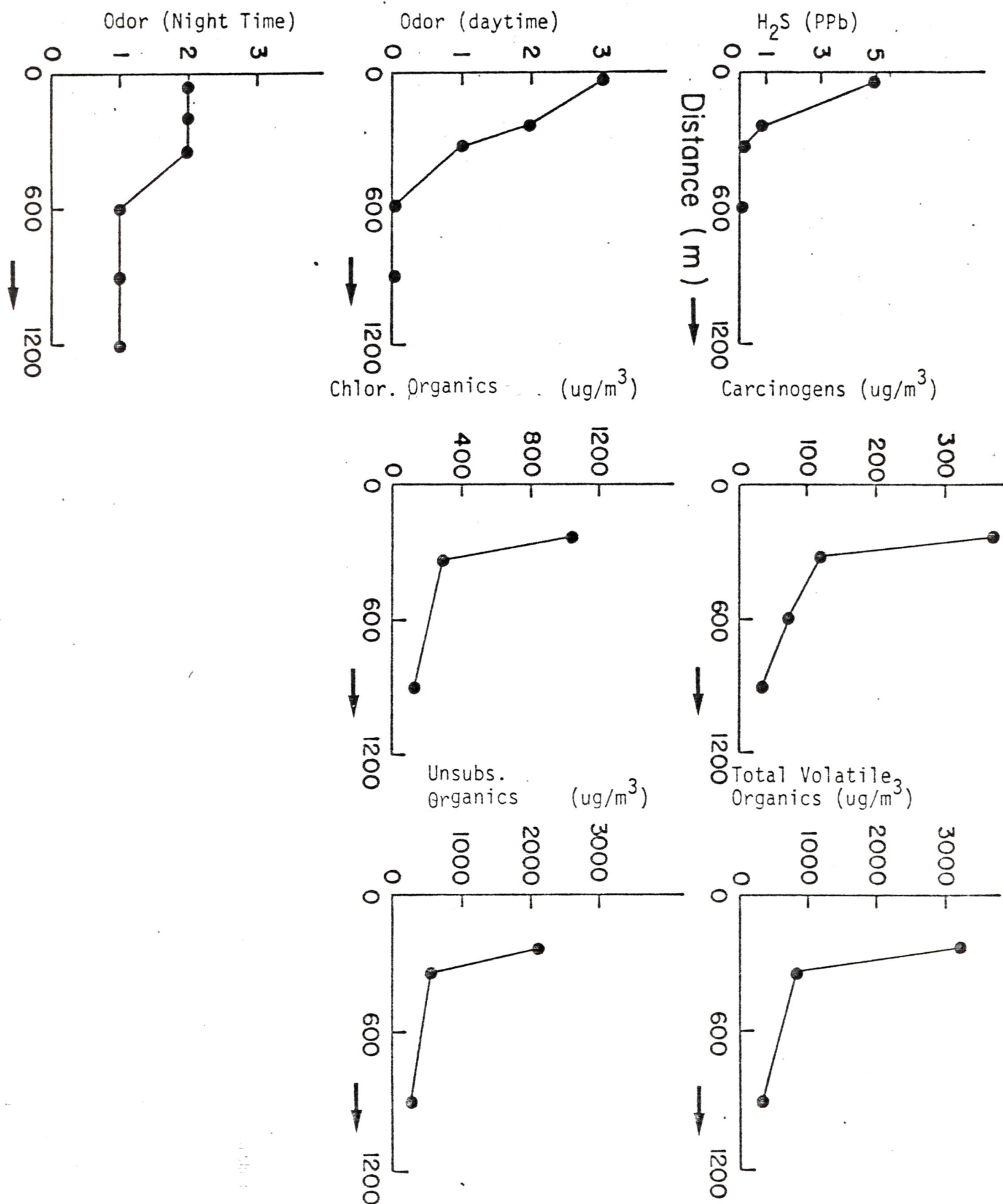
Figure 24 - Distribution of Chlorinated Organics in the Landfill and its Vicinity.



organics, total carcinogens, and total chlorinated organics were plotted against distance from the working face. These major parameters all showed a good correlation between concentrations and distance as presented in figure 25. The measurements were performed downwind, and illustrate the important role of wind direction and velocity in indicating the most affected points of the adjacent area. The important role of wind, as the major dispersion force of odorous compounds was confirmed by the simultaneous collection of two samples, both at a distance of 50 meters from the working face, but one located downwind and one upwind from it. Total volatile organics concentration for these samples were 8,880 and 1,090  $\mu\text{g}/\text{m}^3$  respectively. The fact that the downwind concentration was eight times higher verifies the importance of wind dispersion. The gas burner located at the site disposes the landfill gas by combustion. The chemical composition which tends to make landfill gases odorous and potentially hazardous, also makes it flammable and self-destroying -- a source of useful energy, potentially valuable. Incomplete burning of the recovered gas, however might itself, become a source of pollution. This can be avoided through controlled combustion at elevated temperature.

The importance of the gas burner as source of volatile organics was determined by collecting a series of samples at increasing distances of 0, 300, and 500 meters downwind from the gas burner. The correlation between distance and a number of parameters such as odor, total organics concentration, and chlorinated organics was investigated (Figure 26).

Figure 25 - Correlations of Analytical Parameters with the Distance from the Working Face.

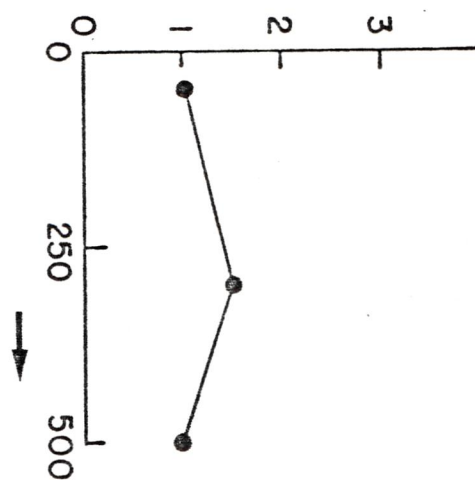
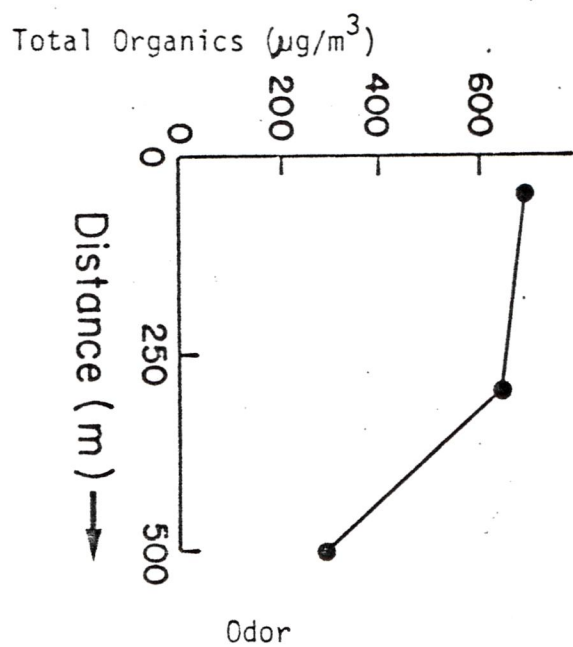
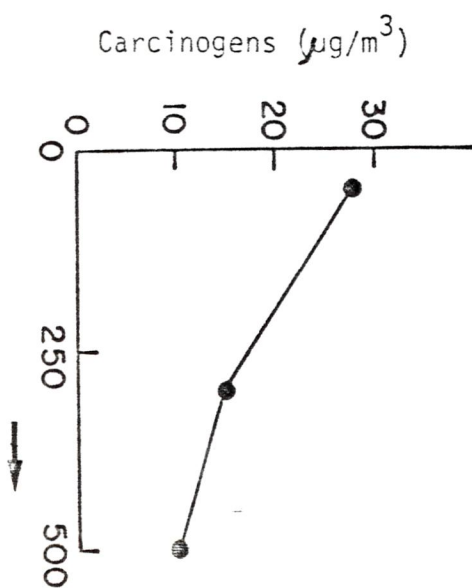
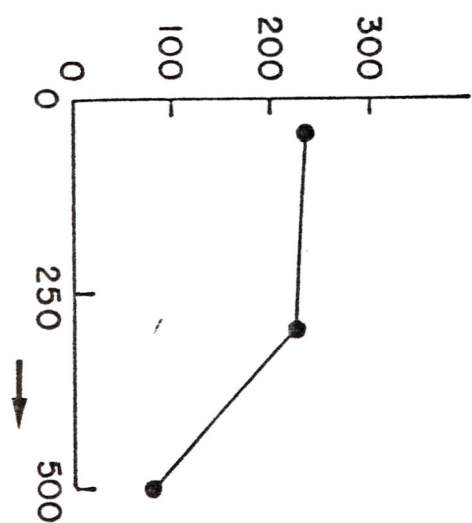
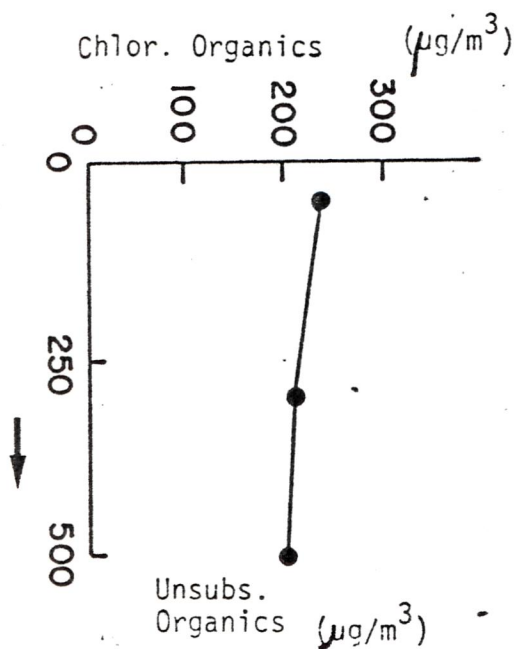


Since the burner combustion temperature is sufficiently high for the oxidation of hydrogen sulfide and other odorous compounds, correlation of odor and distance from the gas burner was found to be insignificant. However, these are some correlations of the concentrations of chlorinated organics, total volatile organics and carcinogenic substances in relation to the distance from the burners. The results shown in Figure 26 suggest that scrubbing the exhaust gas from the burner may reduce slightly the level of organic emission. An after-burner may also be utilized to reduce the emission of refractory organic compounds.

Due to the fact that acid wells are located relatively close to the working face, it is difficult to separate the contribution of odorous compounds from each source. However, estimated olfactory odore around the wells showed usually a high odor nuisance, while organic concentrations were generally low ( $614 \mu\text{g}/\text{m}^3$ ). As it should be suspected, the odor nuisance around these wells is due to inorganic odorous compounds in general, and hydrogen sulfide in particular.

The significance of acid well in emitting odor, is supported by both olfactory study as well as determination of hydrogen sulfide. It should also be noted that different acids can also present pungent odor, which can also be toxic if present in high concentration. Alkaline scrubbing of the emitting gases from acid wells will certainly eliminate a major source of odor emission.

Figure 26 - Correlation Between Analytical Parameters and Distance from the Gas Burner.



#### IV. CONCLUSION AND RECOMMENDATION

The results of this study clearly indicate that there are odor problems associated with the disposal of both solid and liquid wastes in the BKK Landfill Site. The nature of odor emission is intermittent and depends to a great extent on the meteorological condition. The major sources of odor emission are working face and acid wells. Settlement cracks and fissures in the Landfill are insignificant sources. The emission of volatile organic compounds is mostly from the disposal operation. A small quantity is also emitted from gas burner.

The analytical data clearly show that the working face is the major source of emission for odor and volatile organic compounds. A good correlation between the concentration of odor, total volatile organics, chlorinated hydrocarbons, suspected carcinogens and hydrogen sulfide, and proximity to the working face was found during the study. This correlation suggests that one of the techniques in reducing emission is the improvement of operations in the working face.

It has been realized that the open area during the working hours is very wide. This seems to be one of the reasons for the high level of odor and organic concentrations during the day close to the working face. It is suggested that the management try to minimize the exposed face by covering part of the disposal site throughout the day, and concentrating as much as possible on a small area during any period of operation.

The ground level inversion, which prevents mixing of air close to the surface of the landfill, and resulting in a stagnant layer

of air, tends to intensify odor and volatile organics problems in the area. Obviously, one solution to this problem is the reduced exposure of the working face through improvement in the disposal practices.

Other solutions to reduce the emission of harmful and odorous substances from the disposal area would require further study. Possible solutions include (but are not limited to): the selective discharge of benzene and chloroform-containing waste stream into deep wells; physico-chemical treatment of selective incoming waste streams; or source isolation.

The results also indicate that the gas burner, which is located within the landfill is another source of organic emissions. The concentration of volatile organics has been found to be relatively high close to the burner and a good correlation between the organic concentration and proximity to the gas burner was observed. It is strongly suggested that this source of volatile organics be eliminated. Controlled burning at elevated temperature with longer detention time will result in further oxidation and cracking of the carcinogenic compounds into simpler and harmless compounds. Other solutions to this problem include: application of an after-burner or scrubbing the effluent gas for further treatment (e.g. ozonation).

The results of odor evaluation as well as analysis of hydrogen sulfide indicate the gas burner is not a significant source of odor emission. It is reasonable to assume that the current operation is sufficient to destroy odorous compounds. However, further improvement is required to eliminate the emission of refractory organic substances from this source.

Another major source of odor emissions in the landfill is liquid waste disposal wells, especially the sulfuric acid wells. The study showed that intensity of odor as well as hydrogen sulfide concentrations close to these wells are fairly high. A most practical solution to this problem will be the scrubbing of emitting gas in caustic solution.

In comparison with existing standards, it is concluded that the problem at BKK Site is mostly aesthetic in nature. It is believed that substantial improvements can be achieved through implementation of remedial procedures outlined. Further investigations are needed to find suitable methods for reducing the problems associated with the working face.

## V. LIST OF REFERENCES

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## IV APPENDIX

Table A-1

Total Carcinogenic concentrations in the Landfill and its Vicinity

Sample	Station	Time	Date	Benzene $\mu\text{g}/\text{m}^3$	Chloroform $\mu\text{g}/\text{m}^3$	Total Carcinogens $\mu\text{g}/\text{m}^3$
1	L4	Day-time	Dec. 1979	ND	ND	ND
2	W	Day-time	"	ND	ND	ND
3	L1	Day-time	"	ND	31	31
4	L3	Day-time	"	59	53	112
5	L1	3:00 pm	Jan.25,80	13	59	110
6	L3	3:30 pm	"	19	92	111
7	L3	4:00 pm	"	ND	13	13
8	L2	4:30 pm	"	8	59	67
9	L3	2:30 pm	Feb,28,80	11	110	121
10	L3	3:00 pm	"	6	97	103
11	L2	4:00 pm	Mar,7,80	320	ND	320
12	L2	4:30 pm	"	38	190	228
13	*R6	5:00 pm	Mar,8,80	72	79	151
14	R4	12:00 am	Mar,12,80	37	14	51
15	L1	5:00 pm	Mar.21,80	34	ND	34
16	L3	6:00 pm	"	36	ND	36
17	R1	7:00 pm	"	10	ND	10
18	R2	7:30 pm	"	ND	ND	ND
19	R3	8:00 pm	"	30	ND	30
20	R2	3:00 pm	Mar.28,80	56	ND	56

Table A-1  
(Continued)

Sample	Station	Time	Date	Benzene $\mu\text{g}/\text{m}^3$	Chloroform $\mu\text{g}/\text{m}^3$	Total Carcinogens $\mu\text{g}/\text{m}^3$
21	R3	4:00 am	Mar.28,80	44	ND	44
22	R4	5:00 am	"	283	ND	283
23	L1	6:30 am	"	364	ND	364
24	L3	6:50 am	"	104	ND	104
25	R4	12:20 pm	"	20	ND	20
26	L2	4:38 pm	May 17,80	ND	ND	ND
27	L2-L3	4:54 pm	"	ND	47	47
28	L3	5:08 pm	"	41	ND	41
29	L4	5:27 pm	"	13	ND	13
30	L1	5:42 pm	"	16	5	21
31	L1*	5:58 pm	"	3	ND	3
32	L1**	6:11 pm	"	18	ND	18
33	R7	6:42 pm	"	2	3	5
34	R1	7:02 pm	"	27	ND	27
35	R2	7:15 pm	"	11	ND	11
36	R4	7:32 pm	"	16	ND	16
37	L2	9:02 pm	"	10	ND	10
38	L	9:16 pm	"	13	ND	13
39	L3	9:30 pm	"	54	ND	54
40	L4	9:44 pm	"	17	ND	17

Table A-1  
(Continued)

Sample	Station	Time	Date	Benzene $\mu\text{g}/\text{m}^3$	Chloroform $\mu\text{g}/\text{m}^3$	Total Carcinogens $\mu\text{g}/\text{m}^3$
41	L1	10:01 pm	May 17,80	63	ND	63
42	L1*	10:20 pm	"	27	ND	27
43	L1**	11:01 pm	"	5	ND	5
44	R7	11:30 pm	"	45	ND	45
45	R1	11:50 pm	"	9	ND	9
46	R2	00:04 am	"	45	ND	45
47	W	11:39 am	June 17,80	ND	ND	ND
48	L2	11:52 am	"	12	ND	12
49	L3	00:04 pm	"	38	ND	38
50	L1	00:17 pm	"	ND	ND	ND
51	W	:34 pm	"	9	ND	9
52	R1	1:39 pm	"	20	ND	20
53	R2	2:07 pm	"	46	ND	46
54	R7	2:22 pm	"	23	ND	23

D = day time sampling

N = night time sampling

\* = analysis of this sample was stopped by a power break and the data is not reliable, it might only be used as a basis for comparison

L1\* = 300 m Downwind from L1

L\*\* = 500 m Downwind from L1

Table A-2

Chlorinated, Unsubstituted, and Total Volatile Organics Concentrations in the Landfill and its Vicinity

Sample	Station	Time	Date	Total Hydrocarbons $\mu\text{g}/\text{m}^3$	Chlorinated Hydrocarbons $\mu\text{g}/\text{m}^3$	Unsubstituted Hydrocarbons $\mu\text{g}/\text{m}^3$
1	L4	Day-time	Dec. 1979	2440	366	2074
2	W	Day-time	"	6575	555	602
3	L1	Day-time	"	1964	503	146
4	L3	Day-time	"	1601	488	1113
5	L1	3:00 pm	Jan. 25, 80	876	198	596
6	L3	3:30 pm	"	743	147	597
7	L3	4:00 pm	"	29	23	6
8	L2	4:30 pm	"	502	132	370
9	L3	2:30 pm	Feb. 28, 80	795	155	640
10	L	3:00 pm	"	688	182	506
11	L2	4:00 pm	Mar. 7, 80	8881	2140	674
12	L2	4:30 pm	"	1089	209	881
13	*R6	5:00 pm	Mar. 8, 80	2077	123	1945
14	R4	12:00 am	Mar. 12, 80	3438	107	3331
15	L1	5:00 pm	Mar. 21, 80	187	82	105
16	L3	6:00 pm	"	975	18	957
17	R1	7:00 pm	"	202	7	195
18	R2	7:30 pm	"	929	89	840
19	R3	8:00 pm	"	627	34	593
20	R2	3:00 pm	Mar. 28, 80	829	114	714

Table A-2  
(Continued)

Sample	Station	Time	Date	Total Hydrocarbons $\mu\text{g}/\text{m}^3$	Chlorinated Hydrocarbons $\mu\text{g}/\text{m}^3$	Unsubstituted Hydrocarbons $\mu\text{g}/\text{m}^3$
21	R3	4:00 am	Mar. 28, 80	1088	210	878
22	R4	5:00 am	"	2830	185	1898
23	L1	6:30 am	"	3376	1041	2335
24	L3	6:50 am	"	1735	289	1446
25	R4	12:20 pm	"	1328	417	911
26	L2	4:38 pm	May 17, 80	1356	725	631
27	L	4:54 pm	"	2893	1866	1027
28	L3	5:08 pm	"	1037	774	263
29	L4	5:27 pm	"	499	233	266
30	L1	5:42 pm	"	392	247	145
31	L1*	5:58 pm	"	267	187	80
32	L1**	6:11 pm	"	334	225	109
33	R7	6:42 pm	"	419	266	153
34	R1	7:02 pm	"	576	394	182
35	R2	7:15 pm	"	658	467	191
36	R4	7:32 pm	"	419	214	205
37	L2	9:02 pm	"	357	183	174
38	L	9:16 pm	"	461	335	126
39	L3	9:30 pm	"	2058	1294	764
40	L4	9:44 pm	"	1078	745	333

Table A-2  
(Continued)

Sample	Station	Time	Date	Total Hydrocarbons $\mu\text{g}/\text{m}^3$	Chlorinated Hydrocarbons $\mu\text{g}/\text{m}^3$	Unsubstituted Hydrocarbons $\mu\text{g}/\text{m}^3$
41	L1	10:01 pm	May 17,80	698	377	321
42	L1*	10:20 pm	"	1116	239	877
43	L1**	10:01 pm	"	252	179	73
44	R7	11:30 pm	"	600	399	201
45	R1	11:50 pm	"	687	384	303
46	R2	12:04 pm	"	1270	589	681
47	W	11:39 am	June 17,80	2114	332	1782
48	L2	11:52 am	"	475	57	418
49	L3	12:04 pm	"	526	7	519
50	L1	12:17 pm	"	1087	87	1000
51	W	12:34 pm	"	614	61	553
52	R1	1:39 pm	"	396	58	338
53	R2	2:07 pm	"	724	24	700
54	R2	2:22 pm	"	1309	88	1221

See footnote on table A -1

Table A - 3

Estimated Olfactory odor in the Landfill and its Vicinity

Sample #	station	Time	Date	Olfactory odor
1	L4	Day-time	Dec. 1979	1
2	W	Day-time	"	2
3	L1	Day-time	"	1
4	L3	Day-time	"	2
5	L1	3:00pm	Jan. 25,80	1
6	L3	3:30pm	"	2
7	L3	4:00pm	"	1
8	L2	4:30pm	"	0
9	L3	2:30pm	Feb. 28,80	1
10	L	3:00pm	"	2
11	L2	4:00pm	Mar. 7 .80	1
12	L2	4:30pm	"	1
13	*R6	5:00pm	Mar. 8 ,80	0
14	R4	12:00am	Mar. 12,80	0
15	L1	5:00pm	Mar. 21,80	3
16	L3	6:00pm	"	3
17	R1	7:00pm	"	1
18	R2	7:30pm	"	1
19	R3	8:00pm	"	1
20	R2	3:00pm	Mar. 28,80	1

Table A-3  
(Continued)

Sample #	Station	Time	Date	Ofactory odor
21	R3	4:00 am	Mar. 28,80	1
22	R4	5:00 am	"	1
23	L1	6:30 am	"	2
24	L3	6:50 am	"	2
25	R4	12:20 pm	"	0
26	L2	4:38 pm	May 17,80	2
27	L	4:54 pm	"	1
28	L3	5:08 pm	"	2
29	L4	5:27 pm	"	1
30	L1	5:42 pm	"	1
31	L1*	5:58 pm	"	1
32	L1**	6:11 pm	"	1
33	R7	6:42 pm	"	0
34	R1	7:02 pm	"	0
35	R2	7:15 pm	"	0
36	R4	7:32 pm	"	0
37	L2	9:02 pm	"	1
38	L	9:16 pm	"	1
39	L3	9:30 pm	"	2
40	L4	9:44 pm	"	1

Table A-3  
(Continued)

Sample #	Station	Time	Date	Ofactory odor
41	L1	10:01 pm	May 17, 80	1
42	L1*	10:20 pm	"	2
43	L1**	11:01 pm	"	1
44	R7	11:30 pm	"	0
45	R1	11:50 pm	"	0
46	R2	12:04 pm	"	0
47	W	11:39 am	June 17, 80	1
48	L2	11:52 am	"	0
49	L3	12:04 pm	"	1
50	L1	12:17 pm	"	2
51	W	12:34 pm	"	3
52	R1	1:39 pm	"	0
53	R2	2:07 pm	"	0
54	R2	2:22 pm	"	0

\*See footnote on Table A -1

TABLE A4

## ANALYSIS OF SAMPLE COMPOSITION

By  
GC/MS

Sample #1

No.	Identification	Concentration ( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	260
2.	1, 2 Dichloroethane	45
3.	Pentane	44
4.	2, 2 Dimethylbutane	65
5.	Methylcyclopentane	33
6.	2, 3 Dimethylbutane	110
7.	3 - Methylpentane	110
8.	2 - Methylpentane	260
9.	Hexane	190
10.	Methylcyclohexane	87
11.	2, 3 Dimethylpentane	22
12.	Methylhexane	19
13.	Methylethylketone	12
14.	3 - Methylhexane	66
15.	2 - Methylhexane	51
16.	Tetrachloroethene	61
17.	2, 2, 3, 3 Tetramethylbutane	26
18.	Toulene	593
19.	Ethyl Benzene	44
20.	3 - Ethyl 4 - Methylhexane	19
21.	Octane	65
22.	Xylene	210
23.	Possible Ketone	47
24.	Unknown	---
	TOTAL	2439

Sample #2

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	180
2.	1, 2 Dichloroethane	300
3.	Pentane	250
4.	Methylcyclopentane	10
5.	2, 3 - Dimethylbutane	960
6.	3 - Methylpentane	860
7.	2 - Methylpentane	1400
8.	Hexane	300
9.	Methylcyclohexane	71
10.	2, 3 Dimethylpentane	9
11.	Methylhexane	53
12.	2 - Methylhexane	26
13.	Tetrachloroethene	47
14.	Toulene	300
15.	Air	416
16.	Cyclopentane	110
17.	2 Methylbutane	270
18.	Dimethylbutane	910
19.	1, 1, 2, Trichloroethane	28
20.	2, 2, 4, Trimethylpentane	17
21.	Heptane	58
22.	Unknown	---
	TOTAL	6570

Sample #3

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	410
2.	Pentane	93
3.	2, 2, Dimethylbutane	15
4.	2, 3 - Dimethylbutane	26
5.	3 - Methylpentane	40
6.	2 - Methylpentane	100
7.	Hexane	420
8.	Methylcyclohexane	65
9.	3 - Methylhexane	14
10.	2 - Methylhexane	21
11.	Tetrachloroethene	50
12.	Toulene	330
13.	Possible Ketone	59
14.	Air	99
15.	1, 1, 2 Trichloroethane	12
16.	Trichloromethane	31
17.	Dioxane & Isopropanol	39
18.	Ethyl Cyclopentane	8
19.	Heptane	8
20.	Ethylcyclohexane	20
21.	Octane	82
22.	Hexamethylcyclotrisiloxane	22
23.	Unknown	---
	TOTAL	1964

Sample #4

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	260
2.	1, 2, Dichloroethane	62
3.	Pentane	34
4.	2, 2, Dimethylbutane	12
5.	2, 3, Dimethylbutane	19
6.	3 - Methylpentane	17
7.	Hexane	200
8.	Methylcyclohexane	60
9.	2, 3, Dimethylpentane	5
10.	3 - Methylhexane	36
11.	2 - Methylhexane	32
12.	Tetrachloroethene	81
13.	Toulene	300
14.	Possible Ketone	200
15.	Air	61
16.	1, 1, 2, Trichloroethane	32
17.	Ethyl Cyclopentane	7
18.	Octane	46
19.	Benzene	59
20.	Un Sat $\text{C}_8$ Compound	58
21.	Sat $\text{C}_8$ Compound	20
22.	Unknown	—
	TOTAL	1601

Sample #5

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	97.0
2.	Pentane	19.9
3.	Methylcyclopentane	10.9
4.	3 - Methylpentane	8.1
5.	Hexane	
6.	Methylcyclohexane	2.6
7.	3 - Methylhexane	1.9
8.	Tetrachloroethene	4.1
9.	Toulene	25.2
10.	Xylene	16.8
11.	Trichloromethane	97.0
12.	Hexamethyleyclotrisiloxane	120
13.	Benzene	13.3
14.	Isopropanol	4.4
15.	MIBK	1.7
16.	2.4 Dimethylpentane	2.6
17.	Unknown	---
	TOTAL	425

Sample #6

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	16.5
2.	1, 2 Dichloroethane	18.1
3.	Pentane	10.1
4.	Methylcyclopentane	11.2
5.	2, 3 - Dimethylbutane	2.4
6.	3 - Methylpentane	10.8
7.	Hexane	370
8.	Methylcyclohexane	2.3
9.	2 - Methylhexane	3.7
10.	Tetrachloroethene	19.5
11.	Ethyl Benzene	25.5
12.	Trichloromethane	92.5
13.	Hexamethylcyclotrisiloxane	140
14.	Benzene	18.6
15.	4 - Methyl 2 - Pentane	1.8
16.	Unknown	---
	TOTAL	743

Sample #7

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	7.6
2.	Pentane	2.9
3.	Trichloromethane	12.5
4.	Acetone	1.9
5.	2 - Propanol	1.3
6.	Chloroethene	3.2
7.	Unknown	---
	TOTAL	29.4

Sample #8

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	14.7
2.	Hexane	200
3.	Tetrachloroethene	17.0
4.	Ethyl Benzene	29.6
5.	Air	38.8
6.	1, 1 Dichloroethane	41.3
7.	Trichloromethane	59.3
8.	Hexamethylcyclotrisiloxane	88.9
9.	Benzene	7.9
10.	2, 4, Dimethyl 3, Ethylpentane	4.8
11.	Unknown	---
	TOTAL	502

Sample #9

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	11.3
2.	3 - Methylpentane	3.8
3.	Hexane	340
4.	Methylcyclohexane	4.4
5.	3 - Methylhexane	3.2
6.	2 - Methylhexane	3.1
7.	Tetrachloroethene	18.1
8.	Toulene	120
9.	Ethyl Benzene	44.4
10.	Xylene	11.5
11.	Air	3.5
12.	Trichloromethane	110
13.	Ethylcyclohexane	5.6
14.	Hexamethylcyclotrisiloxane	65.5
15.	Benzene	11.2
16.	Chlorobenzene	6.9
17.	Trichloroethene	9.0
18.	2, 2, 4, 6, 6 - Pentamethylheptane	23.6
19.	Unknown	---
	TOTAL	795

Sample #10

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	36.4
2.	Methylcyclopentane	4.6
3.	Hexane	290
4.	Methylcyclohexane	5.9
5.	3 - Methylhexane	3.8
6.	2 - Methylhexane	2.4
7.	Tetrachloroethere	27.8
8.	Ethyl Benzene	5.4
9.	Xylene	14.9
10.	Trichloromethane	97.3
11.	Hexamethylcyclotrisiloxane	100
12.	Benzene	5.8
13.	1, 1, 1, Trichloroethane	10.3
14.	Methyl Pentane	4.3
15.	Trichloroethane	9.7
16.	Methyl Benzene	68.9
17.	Unknown	---
	TOTAL	687

Sample #11

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	38.8
2.	Methylcyclopentane	35.6
3.	Hexane	200
4.	Methylcyclohexane	78.8
5.	2, 3 - Dimethylpentane	34.4
6.	3 - Methylhexane	130
7.	2 - Methylhexane	120
8.	Tetrachloroethane	78.0
9.	2, 2, 3, 3, Tetramethyl Butane	47.6
10.	Toulene	2400
11.	Ethyl Benzene	950
12.	Octane	370
13.	Xylene	3580
14.	Benzene	320
15.	2, 4, Dimethyl Pentane	23.8
16.	2 - Hexane	73.7
17.	Chlorobenzene	23.7
18.	2, 3 - Dimethylhexane	24.5
19.	2, 5 - Dimethylhexane	66.8
20.	2 - Ethoxy - Acetate Ethanol	130
21.	2 - Methylheptane	120
22.	3 - Methyloctane	35.5
23.	Unknown	---
	TOTAL	8881

Sample #12

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Pentane	8.1
2.	Methylcyclopentane	12.0
3.	3 - Methylpentane	8.6
4.	Hexane	240
5.	Methylcyclohexane	3.2
6.	2, 3 - Dimethylpentane	1.0
7.	3 - Methylhexane	7.1
8.	2 - Methylhexane	52.3
9.	Tetrachloroethene	16.2
10.	Toulene	170
11.	Ethylbenzene	47.3
12.	Xylene	110
13.	Trichloromethane	190
14.	Hexamethylcyclotrisiloxane	52.8
15.	Benzene	37.7
16.	Chlorobenzene	2.5
17.	2, 2, 4, 6, 6 - Pentamethylheptane	3.4
18.	1, 3 - Dimethyl-cis Cyclopentane	3.4
19.	1, 3 - Dimethylbenzene	100
20.	Trimethylbenzene	14.3
21.	2 - Methylheptane	9.4
22.	Unknown	---
	TOTAL	1089

Sample #13\*

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Methylcyclopentane	10.8
2.	3 - Methylpentane	8.0
3.	Hexane	340
4.	Methylcyclohexane	3.5
5.	3 - Methylhexane	6.6
6.	2 - Methylhexane	7.9
7.	Tetrachloroethene	26.2
8.	Ethylbenzene	200
9.	Xylene	870
10.	Trichloromethane	79.4
11.	Hexamethylcyclotrisiloxane	230
12.	Benzene	71.6
13.	4 - Methyl 2- Penanone	4.9
14.	1, 1, 1 - Trichloroetane	17.1
15.	Methylbenzene	110
16.	2 - Ethoxy-Acetate Ethanol	14.6
17.	Propylbenzene	33.7
18.	Ethyl Methylbenzene	49.3
19.	Unknown	---
	TOTAL	2084

\*See footnote on Table A-1

Sample #14

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	5.8
2.	Methylcyclopentane	7.2
3.	Hexane	230
4.	Methylcyclohexane	9.3
5.	2, 3 - Dimethylpentane	8.0
6.	3 - Methylhexane	39.8
7.	2 - Methylhexane	31.3
8.	Tetrachloroethene	60.6
9.	Toulene	890
10.	Ethylbenzene	260
11.	Xylene	1480
12.	Trichloromethane	14.2
13.	Hexamethylcyclotrisilexane	138
14.	Benzene	36.9
15.	Acetone	2.6
16.	1, 1, 1 - Trichloroethane	26.5
17.	2 - Methylheptane	25.9
18.	Methylisobatylketone (MIBK)	8.9
19.	Propylbenzene	53.4
20.	1 - Methyl Ethyl Benzene	95.2
21.	5 Methyl, 1 Phenyl, 1 Hexanone	14.1
22.	Unknown	---
	TOTAL	3438

Sample #15

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Methylenechloride	21.7
2.	Freon 113	17.8
3.	1, 2 - Dichloroethane	12.7
4.	Trichloroethene	7.27
5.	Benzene	34.04
6.	Hexane	12.3
7.	Methylcyclohexane	2.14
8.	Tetrachloroethene	14.74
9.	Toluene	19.9
10.	Chlorobenzene	8.03
11.	Hexamethylcyclotrisiloxane	36.4
12.	Unknown	---
	TOTAL	187

Sample #16\*

No.	Identification	$(\mu\text{g}/\text{m}^3)$
1.	Benzene	35.8
2.	Tetrachloroethene	17.2
3.	Toulene	42.5
4.	Hexamethylcyclotrisiloxane	879.8
5.	Unknown	---
<p>*Note: A power failure during the analysis affected the data output. We used the results as a reference only.</p>		
		975
	TOTAL	975

Sample #17

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	1, 1, 2 Trichloro-1, 2, 2 Trifluroethane (Freon)	1.3
2.	1, 2 Dichloroethane	0.5
3.	Benzene	10.4
4.	Hexane	2.7
5.	Tetrachloroethene	3.4
6.	Toulene	8.1
7.	Ethylmethacrylate	1.6
8.	Chlorobenzene	2.8
9.	Ethylbenzene	1.8
10.	Hexamethylcyclsiloxane	155.2
11.	Xylene	10.0
12.	1, 4 Dimethylbenzene	3.9
13.	Unknown	---
	TOTAL	201.8

Sample #18

No.	Identification	(µg/m <sup>3</sup> )
1.	Methycyclopentane	46.3
2.	Toulene	358
3.	Chlorobenzene	88.6
4.	Ethylbenzene	64.5
5.	Xylene	372
6.	Unknown	---
	TOTAL	929

Sample #19

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	5.3
2.	Air	1.6
3.	2 - Propanone (Acetone)	3.8
4.	1, 1 - Dichloroethane	3.7
5.	Freon 113	1.5
6.	1, 2 - Dichloroethane	7.1
7.	Pentane	1.0
8.	1, 1, 1 - Trichloroethane	1.4
9.	Methylcyclopentane	1.1
10.	3 - Methylpentane	0.8
11.	Benzene	30.1
12.	Hexane	9.4
13.	1, 3 - Dimethyl Trans-Cyclopentane	1.3
14.	Methylcyclohexane	2.3
15.	2, 3 - Dimethylpentane	1.0
16.	2 - Hexanone	1.6
17.	3 - Methylhexane	2.7
18.	2 - Methylhexane	2.2
19.	Tetrachloroethene	7.4
20.	Toulene	59.2
21.	Ethylmethacrylate	4.5
22.	Chlorobenzene	7.5
23.	Ethylbenzene	7.3
24.	2 - Methylheptane	1.4
25.	Hexamethylcyclotrisiloxane	413.8
26.	1, 2 - Dimethyl Bezene	47.2
27.	Unknown	---
	TOTAL	626

Sample #20

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	4.8
2.	1, 1 - Dichloroethane	38.0
3.	Freon 113	1.4
4.	1, 2 - Dichloroethane	23.0
5.	1, 1, 1 - Trichloroethane	1.4
6.	Methylcyclopentane	1.2
7.	Benzene	56.1
8.	1, 1, 2 - Trichloroethane	3.1
9.	Hexane	7.8
10.	1, 3 - Dimethylcyclopentane	1.2
11.	Methylcyclohexane	1.4
12.	3 - Methylhexane	2.7
13.	2 - Methylhexane	
14.	Tetrachloroethene	11.1
15.	Toulene	142
16.	Chlorobenzene	31.5
17.	Ethylbenzene	25.0
18.	2, 5 - Dimethylhexane	2.8
19.	Hexamethylcyclotrisiloxane	341
20.	1, 4 - Dimethylbenzene	130
21.	Unknown	---
	TOTAL	828

Sample # 21

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	4.86
2.	1, 1 - Dichloroethane	6.78
3.	1, 1, 2 - Trichloro-1, 2, 2-Trifluoroethane	3.95
4.	1, 2 - Dichloroethane	41.7
5.	1, 1, 1 - Trichloroethane	3.07
6.	Methylcyclopentane	1.40
7.	Trichloroethene	18.9
8.	Benzene	44.2
9.	1, 1, 2 - Trichloroethane	13.27
10.	Hexane	14.8
11.	1, 3 - Dimethyl - Trans-Cyclopentane	2.74
12.	Methylcyclohexane	4.33
13.	3 - Methylhexane	4.22
14.	2, 2, 3 - Trimethylbutane	4.40
15.	Tetrachloroethene	43.3
16.	Toulene	96.2
17.	Hexamethylcyclsiloxane	636
18.	Chlorobenzene	74.5
19.	Ethylbenzene	16.8
20.	2, 5 - Dimethylhexane	4.12
21.	Xylene	48.18
22.	Unknown	---
	TOTAL	1088

Sample # 22

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	13.6
2.	1, 1 - Dichloroethane	19.5
3.	1, 1, 2 - Trichloro-1, 2, 2 - Trifluoroethane	5.86
4.	1, 2 - Dichloroethane	38.97
5.	1, 1, 1 - Trichloroethane	4.13
6.	Methylcyclopentane	3.39
7.	Benzene	283.0
8.	1, 1, 2 - Trichloroethane	22.1
9.	Hexane	31.03
10.	1, 2 - Dimethyl-Transcyclopentane	5.38
11.	Methylcyclohexane	7.05
12.	Heptane	9.53
13.	2, 4 - Dimethylhexane	11.67
14.	Tetrachloroethene	46.5
15.	Chlorobenzene	34.34
16.	Hexamethylcyclotrisiloxane	907.0
17.	Benzaldehyde	27.7
18.	Xylene	1084.0
19.	Propylbenzene	14.1
20.	Ethylbenzene	152.0
21.	1 - Ethyl 3 - Methylbenzene	100.0
22.	1 - Ethyl 2 - Methylbenzene	22.6
23.	Unknown	---
	TOTAL	2844

Sample # 23

No.	Identification	(( $\mu\text{g}/\text{m}^3$ ))
1.	1, 1 - Dichloroethane	278.0
2.	1, 2 - Dichloroethene	28.0
3.	1, 1, 2 - Trichloroethane	7.6
4.	1, 2 - Dichloroethane	255.0
5.	Pentane	5.8
6.	2 - Hexene	4.5
7.	Methylcyclopentane	4.3
8.	Benzene	364.0
9.	1, 1, 2 - Trichloroethane	77.0
10.	Hexane	30.0
11.	1, 3 - Dimethyl - Transcyclopentane	7.3
12.	Methylcyclohexane	13.1
13.	Ethylcyclopentane	4.0
14.	3 - Methylhexane	7.0
15.	$\text{C}_7\text{H}_{16}$	8.1
16.	Tetrachloroethene	154.0
17.	Methylbenzene (Toulene)	502.0
18.	Ethylcyclohexane	86.0
19.	Chlorobenzene	242.0
20.	Ethylbenzene	245.0
21.	2 - Methylheptane	83.5
22.	1, 2, 3 - Trimethylcyclohexane	12.1
23.	Octane	373.0
24.	6 - Methyl 1 - Heptanol	12.0
25.	3 - Ethyl 2, 3 - Dimethylpentane	33.6
26.	1, 3 - Dimethylbenzene	224.0
27.	2, 6 - Dimethylheptane	32.8
28.	2, 3, 4 - Trimethylhexane	18.4
29.	3, 3 - Diethylpentane	15.0
30.	3 - Ethyl 3 - Methylhexene	47.2
31.	Hexamethylcyclotrisiloxane	2020.0
32.	Unknown	---
TOTAL		5194

## Sample # 24

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	9.95
2.	1, 2 - Dichloroethene (Trans)	1.75
3.	1, 1 - Dichloroethane	72.1
4.	1, 2 - Dichloroethene (Cis)	2.97
5.	Freon 113	6.23
6.	1, 2 Dichloroethane	56.1
7.	Pentane	2.83
8.	1, 1, 1 - Trichloroethane	4.19
9.	Methylcyclopentane	2.74
10.	3 - Methylpentane	2.14
11.	Benzene	104
12.	1, 1, 2 - Trichloroethane	16.02
13.	Hexane	24.09
14.	1, 3 - Dimethyl, Trans-Cyclopentane	3.28
15.	Methylcyclohexane	6.53
16.	3 - Methylhexane	5.15
17.	2, 4 - Dimethylhexane	5.62
18.	Tetrachloroethene	57.5
19.	Toulene	204
20.	Ethylcyclohexane	12.9
21.	Chlorobenzene	64.2
22.	Ethylbenzene	44.9
23.	2 - Methylheptane	13.6
24.	Hexamethylcyclsiloxane	901
25.	Dimethylbenzene	67.05
26.	1, 3 - Dimethylbenzene	42.6
27.	Unknown	---
	TOTAL	1733

Sample # 25

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	31.3
2.	2 - Propanone	72.0
3.	Isopropanol	17.5
4.	Unknown	173.7
5.	2 - Butanone	18
6.	1 - Butanol, 2 - Methyl, Acetate	12
7.	Trichloroethane	22
8.	Benzene	199
9.	1, 1, 2 Trichloroethane	10
10.	Hexane	20.8
11.	Methylcyclohexane	13.5
12.	Cyclohexanone	21
13.	2 - Hexanone	41.3
14.	2, 3, 3 - Trimethylhexane	10
15.	Tetrachloroethene	53
16.	2, 2, 4 - Trimethyl, Heptane	596
17.	Toulene	151
18.	Ethylbenzene	64.6
19.	Hexamethylcyclotrisiloxane	19.6
20.	Benzaldehyde	24.4
21.	Xylene	226.2
22.	3 - Chlorotoulene	18.7
	TOTAL	1328

Sample # 26

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	50.2
2.	2 - Propanone	11.4
3.	1, 2 - Dichloro Ethane	115.5
4.	Methylethylketone	7.3
5.	1, 1, 1 - Trichloroethane	11.8
6.	Methylcyclopentane	9.8
7.	3 - Methylpentane	5.1
8.	Benzene	91.1
9.	1, 1, 2 - Trichloroethane	14.5
10.	Hexane	21
11.	1, 3 - Dimethylcyclopentane	11.6
12.	Methylcyclohexane	13
13.	1, 2 - Dimethylcyclohexene	10.3
14.	Cyclohexane one	22.3
15.	Unknown	267
16.	4, 4 - Dimethylheptane	16.7
17.	Tetrachloroethene	56.5
18.	2, 2, 3 - Trimethylpentane	9.9
19.	Toluene	183
20.	Pinene	11.6
21.	Ethylbenzene	51.2
22.	Benzaldehyde	36.8
23.	Xylene	249.9
24.	1 - Chloro-3-Methyl Benzen	43.5
25.	Ethylmethylbenzene	46.1
	TOTAL	1356

Sample # 27

No.	Identification	(µg/m <sup>3</sup> )
1.	Dichloromethane	322
2.	Acetone	52
3.	Trichloromethane	47.0
4.	Ethane, 1, 2 - Dichloro	10.9
5.	Unknown	404
6.	Tetrachloromethane	9.9
7.	Acetic Acid	789.6
8.	Ethoxyethanol	62
9.	Ethanol, 2 - Chloro, Acetate	48
10.	Tetrachloro-Ethene	233.6
11.	Toulene	52.6
12.	Cyclohexane, Ethyl	91
13.	Octenes	123
14.	2 - Octene	85
15.	Cyclotrisiloxane, Hexamethyl	127
16.	4 - Octene	75.7
17.	Benzaldehyde	66.3
18.	Ethylmethylbenzene	293.6
	TOTAL	2893

Sample # 28

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	248
2.	Acetone	65
3.	Isopropanol	7.7
4.	Freon 113	5.7
5.	Ethane, 1, 2 - Dichloro	23.6
6.	Pentane + Methyl ethyl ketone	15.8
7.	Trichloro-Ethene	14
8.	Methylcyclopentane	4.7
9.	Benzene	41
10.	Hexane	22
11.	Cyclopentane, 1, 3 - Dimethyl- Trans-	7.4
12.	Methylcyclohexane	21.7
13.	Hexane, 3 - Methyl	35
14.	Hexane, 2 - Methyl	7.9
15.	Tetrachloroethene	42
16.	Toulene	6.5
17.	Cyclohexane, 1, 1, 3 - Trimethyl	23
18.	Benzeneethyl	77
19.	Cyclotrisiloxane, Hexamethyl	93
20.	Unknown	276
	TOTAL	1031

Sample #29

No.	Identification	(ug/m <sup>3</sup> )
1.	Dichloromethane	49
2.	Acetone	25
3.	Benzene	13
4.	Hexane	19
5.	Ethene, Tetrachloro	15
6.	Toulene	37
7.	2 - Hexene, 2, 3 - Dimethyl	10
8.	Cyclohexane, Ethyl	55.5
9.	Cyclobutanone, 2, 2, 3 - Trimethyl	42
10.	Heptane, 3 - Methylene	24
11.	4 - Octene	97.8
12.	Cyclotrisiloxane, Hexamethyl	70.6
13.	Benzene, 1, 3 - Dimethyl	17.0
14.	Unknown	24
	TOTAL	499

Sample # 30

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	40
2.	Air	13.7
3.	Ethane, 1, 1 - Dichloro	7.6
4.	Trichloromethane	5.0
5.	Ethane, 1, 1, 2 - Trichloro - 1, 2, 2 - Tri- fluoro) = Freon 113	42
6.	Ethane, 1, 2 - Dichloro	26
7.	Ethane, 1, 1, 1 - Trichloro	11
8.	Ethane, Trichloro	7.0
9.	Benzene	16.0
10.	Hexane	11.7
11.	Cyclobentane, 1, 3 - Dimethyl- Trans-	4.9
12.	Cyclohexane, Methyl	8.1
13.	Hexane, 3-Methyl	9.7
14.	Hexane, 2-Methyl	8.2
15.	Ethene, Tetrachloro	24.6
16.	Toulene	75.7
17.	Benzene, Chloro	2.5
18.	Benzene, Ethyl	22.8
19.	Heptane, 2 - Methyl	12.6
20.	Cyclotrisiloxane, Hexamethyl	52.6
21.	Xylene	28.0
	TOTAL	392

Sample # 31

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	38
2.	Acetone	4.3
3.	Ethane 1, 1 - Dichloro	5.5
4.	Ethane, 1, 1, 2 - Trichloro- 1, 2, 2 - Trifluoro = Freon 113	3.0
5.	Ethane 1, 2 - Dichloro	22.0
6.	1, 1, 1, - Trichloroethane	7.9
7.	Ethenetrichloro	12.0
8.	Benzene	2.5
9.	Hexane	7.8
10.	Cyclohexane, Methyl	7.8
11.	Hexane, (E)-Methyl	2.7
12.	Ethane, Tetrachloro	21.0
13.	Toulene	34.5
14.	Benzenemethyl	4.6
15.	Benzene-Ethyl	5.3
16.	Cyclotrisiloxane, Hexanethyl	37
17.	Xylene	11
18	Unknown	40
	TOTAL	267

Sample # 32

No.	Identification	(µg/m <sup>3</sup> )
1.	Methane, Dichloro	18
2.	Ethane, 1, 1 - Dichloro	4
3.	Freon 113	16
4.	Ethane, 1, 2 - Dichloro	16
5.	Cyclopentane, Methyl	26
6.	Ethene, Trichloro	17
7.	Benzene	18
8.	Hexane	5
9.	Methylcyclohexane	19
10.	Cyclopentane, 1, 1, 3 - Trimethyl	10
11.	Ethene, Tetrachloro	21
12.	Toulene	65
13.	Cyclohexane, 1, 1, 3 - Trimethyl	15
14.	Benzene, Ethyl	12
15.	Cyclotrisiloxane, Hexamethyl	58
16.	Xylene	14
	TOTAL	334

Sample # 33

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	28
2.	Acetone	4.7
3.	Freon 113	5.8
4.	1, 2 - Dichloroethane	2
5.	1, 1, 1 - Trichloroethane	2.5
6.	Methylcyclopentane	2
7.	Benzene	1.9
8.	Dimethylcyclopentane	3.1
9.	Hexane	4
10.	Methylcyclohexane	25
11.	3 - Methyltetrahydrothiophene	5.4
12.	Dimethylcyclohexane	78
13.	Tetrachloroethene	7.6
14.	Toulene	35
15.	1, -Ethyl 2 -Methylcyclopentane	11
16.	2, 3, 4 - Trimethyl 2 - Pentene	26
17.	Ethylbenzene	10
18.	2 - Methylheptane	20
19.	Hexamethylcyclotrisiloxane	86
20.	Xylene	61
	TOTAL	444

Sample # 34

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	83
2.	Acetone	23
3.	Isopropanol	10
4.	Diethylether	5.8
5.	1, 2 - Dichloroethane	11
6.	Pentane	9.4
7.	Ethene, Trichloro	8.3
8.	Benzene	27
9.	Hexane	20
10.	Ethene, Tetrachloro	20
11.	Toulene	99
12.	Butane, 2, 2, 3, 3 - Tetramethyl	96
13.	Benzene, Ethyl	23
14.	Cyclotrisiloxane, Hexamethyl	21
15.	Xylene	77
16.	Unknown	12
	TOTAL	575.5

Sample # 35

No.	Identification	(µg/m <sup>3</sup> )
1.	Dichloromethane	12
2.	Acetone	13
3.	Isopropanol	3
4.	Pentane	4
5.	Benzene	11
6.	Hexane	6.5
7.	Tetrachloroethene	6.4
8.	Toulene	48
9.	Siloxane	340
10.	Ethylbenzene	32
11.	4 - Ethyl 2 - Methylhexane	25
12.	Unknown	45
13.	Hexamethylcyclotrisiloxane	51
14.	Xylene	61
	TOTAL	658

Sample #36

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Methane, Dichloro	97
2.	2 - Propanone	23
3.	Freon 113	9.6
4.	Pentane	7.2
5.	Benzene	16
6.	Hexane	8.4
7.	Cyclohexane, Methyl	3.7
8.	Heptane	3.5
9.	Heptane, 3 - Methyl	2.7
10.	Ethene, Tetrachloro	3.9
11.	Toulene	64
12.	Siloxane	25
13.	Unknown	63
14.	Cyclohexane, 1,1, 3 - Trimethyl	7.8
15.	Benzene, Ethyl	9.7
16.	Cyclotrisiloxane, Hexamethyl	25
17.	Xylene	49
TOTAL		418.5

Sample # 37

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloro-Methane	130
2.	Acetone	31
3.	Freon 113	65
4.	Ethane, 1, 2 - Dichloro	8.6
5.	Pentane	8.3
6.	Ethane, 1, 1, 1 - Trichloro	6.4
7.	Benzene	9.5
8.	Hexane	9.8
9.	1 - Pentene, 3, 4 - Dimethyl	4.2
10.	Cyclohexane, Methyl	9.2
11.	Hexane, 3 - Methyl	8.3
12.	2 - Methylhexane	4.6
13.	Toulene	12
14.	Siloxane	31
15.	Cyclotrisiloxane, Hexamethyl	19
	TOTAL	357

Sample # 38

No.	Identification	(µg/m <sup>3</sup> )
1.	Dichloromethane	198
2.	Acetone	41
3.	Isopropanol	7.2
4.	Ethane, 1, 2 - Dichloro	21
5.	Pentane	10
6.	Methylcyclopentane	3.4
7.	Ethene, Trichloro	9.2
8.	Benzene	13
9.	4 - Methylpentene	3.7
10.	Hexane	18
11.	Cyclohexane, Methyl	3.7
12.	Methylisobutylketone	3.7
13.	Pentane, 2, 3 - Dimethyl	4.7
14.	Heptane, 3 - Methyl	3.8
15.	Ethene, Tetrachloro	13
16.	Toluene	53
17.	Benzene, Ethyl	5.5
18.	Cyclotrisiloxane, Hexamethyl	26
19.	Xylene	23
	TOTAL	461

## Sample # 39

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloro-Methane	380
2.	Acetone	120
3.	Carbon Disulfide	11
4.	Isopropanol	44
5.	Diethylether	36
6.	Freon 113	37
7.	Ethane, 1, 2 - Dichloro	25
8.	Pentane	100
9.	Trichloroethene	16
10.	Cyclopentane, Methyl	7.9
11.	Ethene, Trichloro	36
12.	Benzene	54
13.	Hexane	80
14.	Cyclopentane, 1, 2 - Dimethyl-Cis	9
15.	Cyclohexane, Methyl	16
16.	Hexane, 3 - Methyl	14
17.	Hexane, 2, 3, 3 - Trimethyl	9.1
18.	Ethene, Tetrachloro	37
19.	Cyclopentane, 1, 2, 3 - Trimethyl	6.7
20.	Toluene	91
21.	Cyclohexane, Ethane	22
22.	2 - Pentene, 2, 3, 4 - Trimethyl	29.5
23.	Xylene	88
24.	Octamethylcyclotetrasiloxane	680
25.	Possibly Saturated Hydrocarbon	826
26.	Benzene, Ethyl	19
27.	Cyclotrisiloxane Hexamethyl	64
TOTAL		2058

Sample # 40

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	59
2.	Acetone	13
3.	Freon 113	12
4.	Pentane	13
5.	Benzene	17
6.	Hexane	15
7.	Cyclohexane, Methyl	12
8.	Heptane	18
9.	Hexane, 2, 3, 3 - Trimethyl	10
10.	Ethene, Tetrachloro	6.9
11.	Toulene	120
12.	Siloxane	440
13.	Benzene, Ethyl	49
14.	Heptane, 2 - Methyl	43
15.	Unknown	47
16.	Cyclotrisioxane, Hexamethyl	59
17.	Xylene	119
18.	Benzene, 1 - Ethyl 3 - Methyl	25
	TOTAL	1078

Sample # 41

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichlormethane	45
2.	Acetone	9.5
3.	Isopropanol	11
4.	Ethane, 1, 2 - Dichloro	38
5.	Pentane	21
6.	Cyclopentane, Methyl	5.6
7.	Benzene	63
8.	Hexane	22
9.	Unknown	159.1
10.	Hexane, 2, 3, 3 - Trimethyl	9.2
11.	Ethene, Tetrachloro	11
12.	Toluene	220
13.	Benzene, Ethyl	10
14.	Heptane, 2 - Methyl	8
15.	Cyclotrisioxane, Hexamethyl	27
16.	Xylene	39
	TOTAL	698.4

Sample #42

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	136
2.	Acetone	25
3.	Isopropanol	13
4.	1, 1 - Dichloroethane	68
5.	Freon 113	16
6.	1, 2 - Dichloroethane	48
7.	Pentane	48
8.	Methylcyclopentane	15
9.	Benzene	27
10.	Hexane	27
11.	Methylcyclohexane	14
12.	Methyisobutylketone	36
13.	3 - Methylhexane	21
14.	2, 3, 3 - Trimethylhexane	13
15.	Tetrachloroethene	77
16.	Toulene	188
17.	Ethylbenzene	45
18.	Hexamethylcyclotrisiloxane	77
19.	Xylene	222
	TOTAL	1116

Sample # 43

No.	Identification	(µg/m <sup>3</sup> )
1.	Dichloromethane	92
2.	Acetone	22
3.	Isopropanol	9.4
4.	Diethylether	4.5
5.	Freon 113	4.1
6.	1, 2 - Dichloroethane	3.6
7.	Pentane	14.7
8.	Trichloroethene	2.8
9.	Benzene	5.2
10.	Hexane	7.2
11.	Tetrachloroethene	7.8
12.	Toulene	15.9
13.	Hexamethylcyclotrisiloxane	50
14.	Xylene	12.3
	TOTAL	251.5

Sample # 44

No.	Identification	(µg/m <sup>3</sup> )
1.	Dichloromethane	54
2.	Acetone	14
3.	Air	11
4.	Ethane, 1, 1 - Dichloro	37
5.	Ethane, 1, 2 - Dichloro	12
6.	Pentane	18
7.	Ethene, Trichloro	8.3
8.	Benzene	45
9.	Hexane	16
10.	Hexane, 3 - Methyl	9
11.	Hexane, 3 - Methyl	8.1
12.	Ethene, Tetrachloro	15
13.	Toulene	1.7
14.	Benzene, Ethyl	63
15.	Silane, 2 - Ethoxyethoxy, Trimethyl	22
16.	Cyclotrisiloxane, Hexamethyl	35
17.	Xylene	210
18.	Benzene, 1 - Ethyl 4 - Methyl	21
	TOTAL	600

Sample # 45

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Methane, Dichloro	249
2.	Acetone	39
3.	Ethylether	5.1
4.	Freon 113	4.0
5.	Ethane 1, 3, Dichloro	6.7
6.	Pentane	18.4
7.	Ethene, Trichloro	6.4
8.	Benzene	8.7
9.	Hexane	13
10.	1, 4 - Hexadiene, 3 - Ethyl	4.0
11.	Hexane, 3 - Ethyl 4 - Methyl	35.9
12.	Ethene, Tetrachloro	20.6
13.	Toulene	38
14.	Ethyl Benzene	47.9
15.	Cyclotrisiloxane, Hexamethyl	37.4
16.	Xylene	59
17.	Ethylmethylbenzene	39
18.	Unknown	54.8
	TOTAL	687

Sample # 46

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	310
2.	Acetone	77.9
3.	2 - Propanol	66.5
4.	Freon 113	58
5.	1, 2 - Dichloroethane	12.6
6.	Pentane	111.6
7.	1, 1, 1 - Trichloroethane	13.0
8.	1, 4, Dioxane	9.8
9.	Cyclopentane, Methyl	10
10.	Furan Tetrahydro 2 - Methyl	9.5
11.	Benzene	44.5
12.	1, 1, 2 - Trichloroethane	9.7
13.	Hexane	117.9
14.	1 - Pentene, 3, 4 - Dimethyl	8.4
15.	Cyclohexane, Methyl	13.8
16.	Methylisobutyketone	26.9
17.	Hexane, 3 - Methyl	12.9
18.	Hexane, 2 - Methyl	12.8
19.	Ethene, Tetrochloro	33.8
20.	Pentane, 3, 2, 4 - Trimethyl	9.2
21.	Toulene	122
22.	Heptane 3 - Methyl	5.5
23.	Possible Silicon Compound	7.4
24.	Cyclotrisiloxane, Hexamethyl	41.0
25.	Heptane 2, 3, 4 - Trimethyl	11
26.	Unknown	145
TOTAL		1270

Sample # 47

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Acetone	28.9
2.	2 - Isopropanol	15.8
3.	Ethane, 1, 1, 2 - Trichloro 1, 2, 2 - Trifluoro	19.5
4.	Methyle	15.9
5.	Pentane	5.5
6.	Ethane, 1, 1, 1 - Trichloro	79.3
7.	Aceticacidethylester	19.4
8.	Cyclopentane, Methyl	21.6
9.	Unknown	12.6
10.	Trichloroethene	30.9
11.	Ethane, 1, 1, 2 - Trichloro	10.5
12.	Hexane	138.5
13.	Cyclopentane, 1, 3 - Dimethyl-, Trans-	31.0
14.	Cyclohexane, Methyl	41.9
15.	Cyclopentane, Ethyl	11.4
16.	2 - Pentanone, 4 - Methyl	19.2
17.	Heptane, 3, 4 - Dimethyl	23.3
18.	Hexane, 2 - Methyl	12.2
19.	Ethene, Tetrachloro	67.2
20.	Stoluene	433.2
21.	Cyclopentane, 1 - Ethyl 3 - Methyl, Cis-	13.4
22.	Unknown	36.4
23.	Chlorobenzene	22.2
24.	Cyclohexane, 1, 2 - Dimethyl, Trans-	11.1
25.	Cyclohexane, 1, 1, 3 - Trimethyl	42.8
26.	Unknown	16.6
27.	Benzene, Ethyl	68.6
28.	Heptane, 2 - Methyl	25.5
29.	Octane	55.2
30.	Benzene, 1, 3 - Dimethyl (Xylene)	160.9
31.	Benzene, 1, 3 - Dimethyl (Xylene)	160.2
32.	4 - Methylbenzaloehyde	28.5
33.	Heptane, 5 - Ethyl 2 - Methyl	36.6
34.	Heptane, 4 - (1-Methylethyl)-	36.5
35.	Heptane	43.3
36.	Unknown	63.7
37.	Unknown	221.7
	TOTAL	2114

Sample # 48

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Dichloromethane	17.9
2.	2 - Propanol (Isopropanol)	9.1
3.	1, 2 - Dichloroethane	6.2
4.	1, 4 - Dioxane	7.1
5.	Benzene	12.3
6.	Hexane	29.8
7.	Methyl Cyclohexane	5.9
8.	Ethene, Tetrachloro	19.6
9.	Toulene	51.4
10.	Benzene, Chloro	13.1
11.	Dimethylcyclohexane	19.7
12.	Trimethylcyclohexane	14.3
13.	Benzene, 1, 3 - Dimethyl	19.1
14.	Unknown Hydrocarbon	220.1
15.	Unknown	29.4
	TOTAL	475

Sample # 49

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Pentane	7
2.	Benzene	38
3.	Hexane	4
4.	Unknown	4
5.	Cyclohexane, Methyl	7
6.	Hexane, 3 - Methyl	5
7.	Hexane, 2 - Methyl	13
8.	Ethene, Tetrachloro	7
9.	Benzene, Methyl	150
10.	Unknown	6
11.	Pentane, 2, 2 - Dimethyl	11
12.	Heptane, 2 - Methyl	9
13.	Unknown	9
14.	Unknown	204
TOTAL		474

Sample # 50

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	2 - Propanol	8.6
2.	Ethane, 1, 1, 2 - Trichloro 1, 2, 2 - Trifluoro	13.9
3.	Ethane, 1, 2 - Dichloro	10.3
4.	Ethane, 1, 1, 1 - Trichloro	37.7
5.	Cyclopentane, Methyl	5.2
6.	Pentane, 3 - Methyl	6.1
7.	Unknown	16.8
8.	Hexane	94.8
9.	Cyclohexane, Methyl	5.1
10.	2 - Pentanone, 4 - Methyl	4.1
11.	Hexane, 3 - Methyl	3.7
12.	Ethene, Tetrachloro	25.2
13.	Toluene	74.3
14.	Benzene, Ethyl	14.4
15.	Hexane, 2, 4 - Dimethyl	9.6
16.	Xylene	29.7
17.	Xylene	28.3
18.	Heptane, 3, 3, 5 - Trimethyl	75.9
19.	Heptane, 3 - Ethyl	61.7
20.	Hexane, 2, 2, 5 - Trimethyl	561.2
21.	Methylenechloride	17
22.	Acetone	10
	TOTAL	1087

Sample # 51

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Methane, Dichloro	12.0
2.	Methane, Dichloro	22.5
3.	Acetone	3.3
4.		17.9
5.	2 - Propanol	11.4
6.	Ethane, 1, 1, 2 - Trichloro 1, 2, 2 - Trifluoro (Freon 113)	7.1
7.	1, 2 - Dichloroethane	12.6
8.	Pentane	8.0
9.	1, 1, 1 - Trichloroethane	9.2
10.	Benzene	18.6
11.	Hexane	57.5
12.	Cyclohexane, Methyl	8.4
13.	Hexane, 3 - Methyl	3.5
14.	Ethene, Tetrachloro	17.6
15.	Toulene	59.8
16.	Hydrocarbon	22.0
17.	Octane, 3 - Methyl	277.5
18.	Unknown	43.4
	TOTAL	614

Sample # 51

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Methane, Dichloro	12.0
2.	Methane, Dichloro	22.5
3.	Acetone	3.3
4.		17.9
5.	2 - Propanol	11.4
6.	Ethane, 1, 1, 2 - Trichloro	
	1, 2, 2 - Trifluoro (Freon 113)	7.1
7.	1, 2 - Dichloroethane	12.6
8.	Pentane	8.0
9.	1, 1, 1 - Trichloroethane	9.2
10.	Benzene	18.6
11.	Hexane	57.5
12.	Cyclohexane, Methyl	8.4
13.	Hexane, 3 - Methyl	3.5
14.	Ethene, Tetrachloro	17.6
15.	Toulene	59.8
16.	Hydrocarbon	22.0
17.	Octane, 3 - Methyl	277.5
18.	Unknown	43.4
	TOTAL	614

Sample # 52

No.	Identification	(µg/m <sup>3</sup> )
1.	Methane, Dichloro	25
2.	2 - Propanone	16
3.	Freon 113	9
4.	Ethane, 1, 1, 1 - Trichloro	9
5.	Benzene	20
6.	Hexane	37
7.	Ethene, Tetrachloro	15
8.	Benzene, Methyl	106
9.	Ethel Benzene	35
10.	Xylene	53
11.	Xylene	55
12.	Unknown	15
	TOTAL	395

Sample # 53

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	Unknown	5
2.	Unknown	11
3.	Freon 113	8
4.	Unknown	5
5.	Unknown	2
6.	Unknown	2
7.	Unknown	3
8.	Benzene	46
9.	Hexane, 3 - Methyl	3
10.	Hexane, 2 - Methyl	10
11.	Unknown Hydrocarbon	13
12.	Ethene, Tetrachloro	24
13.	Unknown	7
14.	Benzene, Methyl	137
15.	Benzene, Ethyl	18
16.	Unknown	14
17.	Benzene, 1, 3 - Dimethyl (Xylene)	92
18.	Benzene, Dimethyl (Xylene)	62
19.	Benzene, Propyl-	20
20.	Benzene, Propyl-	14
21.	Benzene, 1 - Ethyl 4 - Methyl	59
TOTAL		575

Sample # 54

No.	Identification	( $\mu\text{g}/\text{m}^3$ )
1.	2-Propanone	26
2.	2-Propanol	19.2
3.	Ethane, 1,1,2-Trichloro-1,2,2 - Trifluoro	20.1
4.	Ethane, 1,1,1-Trichloro-	47.1
5.	Cyclopentane, Methyl-	8.8
6.	Pentane, 3-Methyl-	6.1
7.	Benzene	22.4
8.	Hexane	124.8
9.	Cyclohexane, Methyl	6.9
10.	2-Hexanone	6.7
11.	Ethene, Tetrachloro-	20.5
12.	1,3 Toluene	126.2
13.	Benzene, Ethyl-	28.9
14.	Hexane, 2,4-dimethyl-	10.9
15.	Benzene, 1,3-Dimethyl- Xylene	45.1
16.	Xylene	45.1
17.	Unknown	97.5
18.	Unknown	16.0
19.	Heptane, 4-(1-Methylethyl)-	82.3
20.	Unknown	35.8
21.	Unknown	50.8
22.	Methylene Chloride	52
	TOTAL	1306

Table A - 5

Hydrogen sulfide analysis in the Landfill and its Vicinity

Concentration (PPb) Station	Day	Night
L1	4.85	2.7
L2	5.75	3.6
L3	0.61	1.8
L4	0.09	0.7
R1	0	0.2
R2	0	1.05
R3	0	1.25
R4	0.63	1
R5	0	0.3
R6	0	0.1
R7	0	0.2

Table A - 6

Concentration - Distance Correlation Around The Gas Burner

Distance From Gas Burner Parameter	50 (m)	300 (m)	500 (m)
Total Volative Organics ( $\mu\text{g}/\text{m}^3$ )	725	691	293
Olfactory Odor	1	1.5	1
Chlorinated Hydrocarbons ( $\mu\text{g}/\text{m}^3$ )	237	213	202
Carcinogens ( $\mu\text{g}/\text{m}^3$ )	28	15	12

Table A - 7

Concentrations -Distance Correlation Around The Working Face

Distance Parameter	50 (m)	250 (m)	350 (m)	600 (m)	900 (m)	1200 (m)
Total volatile Organics ( $\mu\text{g}/\text{m}^3$ )	*	2132	542	*	269	*
( $\mu\text{g}/\text{m}^3$ ) Chlorinated Hydrocarbons	*	1041	289	*	162	*
Total Carcinogens ( $\mu\text{g}/\text{m}^3$ )	*	364	104	56	36	0
Olfactory Odor	3	2	1	0	0	0
Hydrogen - Sulfide (ppb)	5	0.83	0.09	0	0	0

\* Data not available